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40TH CONGRESS, 3d Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. 1, pt. 2.

MESSAGE

OF THE

PRESIDENT OF THE UNITED STATES

AND

ACCOMPANYING DOCUMENTS,

TO THE

TWO HOUSES OF CONGRESS

AT THE

COMMENCEMENT OF THE THIRD SESSION OF THE FORTIETH CONGRESS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1869.

REPORT

OF THE

SECRETARY OF WAR.

PART II.

REPORT

OF

THE CHIEF OF ENGINEERS.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., October 20, 1868.

GENERAL: I have the honor to present the following report of the operations of the corps of engineers for the fiscal year ending June 30, 1868.

OFFICERS OF THE CORPS OF ENGINEERS.

The number of officers in the corps of engineers at the end of the year was 114 on the active list, and five on the retired.

Eight officers were added to the corps by promotion of graduates of the Military Academy. No casualties have occurred in the corps during the past year.

On the 30th of June, 1868, the officers were distributed as follows:

On duty at the headquarters of the corps	6
On duty with boards of engineers for fortifications	8
On duty with battalion of engineers	21
On duty, construction of fortifications	13
On duty, construction of fortifications and harbor and river improvements	21
On duty, harbor and river improvements	14
On duty, survey of the lakes	9
On special duty	2
On detached duty	15
Retired, off duty	2
Graduates Military Academy, on graduating leave	8
Total	119

The officers detached were on duty as follows:

Members of the Light-house Board, Brigadier General *Richard Delafield*, brevet major general United States army, and Colonel *Hartman Bache*, brevet brigadier general United States army	2
Engineer secretary to Light-house Board, Major *O. M. Poe*, brevet brigadier general United States army	1
Aides-de-camp to the General of the army, Major *C. B. Comstock*, brevet brigadier general United States army, and Major *O. E. Babcock*, brevet brigadier general United States army	2
On staff of Lieutenant General, commanding military division of the Missouri, Major *W. E. Merrill*, brevet colonel United States army	1
On staff of major general commanding military division of the Pacific, Major *H. M. Robert*	1

On duty under the immediate orders of the honorable Secretary of the Interior, Captain *C. W. Howell*, brevet major United States army. 1
On staff of brevet major general commanding department of the Platte, First Lieutenant *R. W. Petriken*..... 1
On duty at the Military Academy, Captain *P. S. Michie*, brevet lieutenant colonel United States army, Captain *W. H. H. Benyaurd*, brevet major United States army, First Lieutenant *M. B. Adams*, First Lieutenant *J. C. Post*, First Lieutenant *H. M. Adams*, and First Lieutenant *James Mercur*..... 6

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The following officers of infantry were on duty during the year under my orders: Lieutenant Colonel *J. H. Wilson*, thirty-fifth infantry, brevet major general United States army, Second Lieutenant *E. T. Hoffman*, thirty-fifth infantry, and the following civil engineers under the authority of the Secretary of War were employed, namely: Messrs. *W. Milnor Roberts*, *D. C. Jenné*, *H. C. Long*, and *Clarence King*.

SEA-COAST AND LAKE FRONTIER DEFENCES.

Material progress has been made during the year upon those portions of the defences not affected by the questions, now prominent, respecting the increased use to be made of iron in covering and protecting guns, gunners, and scarps, against the action of projectiles of very large calibres, served from armored batteries. It has been found practicable to advance the condition of the fortifications very sensibly in many particulars, although the appropriations for this object have been quite restricted, and much within the amounts asked for for this service. The construction of walls, piers, and arches; of casemates, quarters, storerooms, and magazines, foundations, counterscarps, and other parts of our defensive works, can be continued with advantage, independently of the special question of armor, which exacts deliberate and prolonged examination here, as well as in other countries.

The work of restoration on the forts on the southern sea-coast has been continued, so that a large portion of the defences of New Orleans, as well as Mobile and Pensacola, have been placed again in condition for use.

A careful inspection has been made by an experienced engineer officer of the defences of the southern Atlantic coast, between Cape Henry and Cape Florida; their condition ascertained, and projects and estimates prepared for their restoration to a serviceable condition as well as for desirable modifications and improvements. Whenever it shall be considered expedient to undertake these meliorations, and Congress shall make the necessary appropriations, officers of engineers can be put upon this duty, and the work be commenced.

Inspections of the works in progress on the Pacific coast, as well as examinations of existing defences, proposed sites, and the frontier and sea-board lines of that coast, have been made by Lieutenant Colonel B. S. Alexander, brevet brigadier general United States army; and the board of engineers, of which that officer is the presiding member, has had under consideration, and acted upon, a number of important questions pertaining to the defence of that coast, which were committed to it for examination. These questions include selections of sites for defensive works, direction of surveys, with the determination of their extent

character, preparation of projects of fortifications, and examinations
he plans of forts under construction with a view to their melioration
improvement.

he special examinations and experiments in progress for the purposes
evising suitable methods of applying and serving enlarged artillery
he sea-coast batteries and forts, and of protecting our defences
nst attacks strengthened by such artillery and protection, have not
afforded all the desired conclusions. The undeveloped condition of
nches of manufacturing industry, the gravity of the subject, and
r causes external to the professional questions involved, have de-
d the progress of the investigations. But this delay has at least
rged the field of examinations and opened channels of intelligence,
use of which will eventually render more full and complete the solu-
of the question.

mong these inquiries may be mentioned a series of experiments, on
educed scale, made by Captain W. R. King, brevet major United
es army, with steel projectiles of various forms, and with plates of
and of steel, of various qualities, thicknesses, forms, and combina-
s.

hese experiments are being carried on with a view to ascertaining
relative resistances to penetration of the metals tested, and such other
lities as could be determined in this manner. They may be followed
xperiments on a larger scale, in such cases as from their importance
require it.

hese experiments, and the investigations to which they lead, were
rded chiefly as finders; that is, where undertaken with a view to re-
ing the number and cost of the larger experiments.

heir results are valuable, giving facts concerning the laws of pene-
ion of solid wrought-iron plates; of laminated plating; of combina-
s of wrought and chilled cast iron; of cast and rolled Bessemer steel;
enetration in sand; and the effect of different forms of head upon
penetrating power of the projectile.

esides revisory examinations of projects for the modification of
ting forts, and of works in progress, extended and varied experi-
nts upon materials and combinations for parapets have been made by
board of engineers for fortifications, Colonel J. G. Barnard, brevet
or general United States army, presiding officer, including earth of
erent kinds, several sorts of masonry, metal plates, and these several
nents applied together in various ways; the results of which have
n to afford the knowledge requisite for the preparation of suitable
er for open batteries in a large portion of cases, and for important
itions.

everal experimental structures, into which iron enters as the special
nent, have also been made ready for trial under the direction of the
rd of engineers for fortifications, and these will soon be subjected to
per tests, carefully applied. These structures represent the appli-
ion of this material both to open and covered batteries, and to existing
ks as well as in new ones. The trials executed and proposed will
refore, together, provide for all the cases belonging to our system of
st defences.

Another question which is receiving the attention of the corps of
gineers, is one which has lately been reopened by the direction which
eriments in England have taken, viz: whether it may not be better
eek some arrangement for mounting barbette guns which will allow
gun to descend, either during or after the recoil, so as to bring it
ler cover of the parapets, and thus avoid the expense of constructing
n shields or embrasures for barbette guns.

This question has been heretofore studied by several officers of the corps at various times, and models and drawings of several devices for the purpose have been made. The interest in this subject has been renewed by the recent trials of Captain Moncrieff's counterpoise barbette carriage for a seven-inch rifle, at Shoeburyness, which is represented to be a successful solution of the problem.

The estimates of appropriations for the fiscal year ending June 30, 1870, are based upon the most moderate progress in the defences; and this only upon those portions of them which are not affected by the questions of cover, or armor, discussed above. It is for the interest of the country, in respect to its seaboard defences, that these amounts, at least, should be appropriated, to be promptly applied to the works. There are no questions in debate that touch the judicious and economical expenditure of these sums. Several of the forts are suffering by the delay and interruptions of labor. At some of them the encroachments of the sea are causing serious injury to the sites, which, if not arrested, will prove destructive to portions of the defences.

FORTIFICATIONS.

Fort Wayne, Detroit, Michigan, in charge of Colonel T. I. Cram, brevet major general United States army.—Operations at this work during the year have resulted as follows: The ditch has been widened to 25 feet, and about 900 square yards of the counterscarp have been graded and sodded. The glacis has been graded opposite the east face of the north bastion, and 2,000 cubic yards of earth embanked on other portions. The lateral batteries have been laid out, and about 6,000 cubic yards of earth from the ditch embanked along the lines of their parapets. The concrete covering has been applied to the magazine in the demilune. The stone coping of the face wall of this magazine has been completed, as also the brick wall to sustain the earth covering at the extremity next to the salient gun platform, and the doors have been made and hung. The excavation for the foundation of the magazine in the west battery has been completed, and the doors for this magazine, and also that in the east battery, made. The ramp leading from the roadway up the glacis to the ditch opposite the sallyport, under the north flank of the east bastion, has been finished. A new main roadway to replace the existing one has been located and graded. The drain leading along the rear of soldiers' quarters has been rebuilt and enlarged, and the ditch drain and main gateway completed.

During the present year it is contemplated to complete the magazine, and the 15-inch gun platform in the demilune; to construct breast heights, gun platforms, magazines, and parapets of lateral batteries; to complete the grading, sodding, and seeding of counterscarp and glacis; to reconstruct roadway from main entrance to engineer wharf, and execute such incidental work of repairs as may be found necessary.

Appropriation asked for the next fiscal year, $20,000.

Fort Porter, Black Rock, near Buffalo, New York, in charge of Colonel T. J. Cram, brevet major general United States army, and Captain F. Harwood, brevet lieutenant colonel United States army.—Operations during the year were confined to repairs of temporary buildings for storage and office purposes.

No appropriation asked for the next fiscal year.

Additional works for the defence of Buffalo, New York.—The condition of these remains the same as was reported last year.

No appropriation asked for the next fiscal year.

Fort Niagara, mouth of Niagara river, New York, in charge of Colonel

T. J. Cram, brevet major general United States army, and Lieutenant Colonel C. E. Blunt, brevet colonel United States army.—Comparatively little has been done at this work since operations were suspended in October, 1866.

The principal work executed has been the completion of the sallyport arch with its roof surfaces, and of the other arches of the land front, with the covering of mastic on part of the left flank, and the carrying up of the dry stone wall back of the scarp.

The succeeding operations to be undertaken are the stone coping of the scarp, building entrances and stairways to flank casemates and gallery at re-entrant, and embanking of the land front parapet.

Appropriation asked for the next fiscal year, $25,000.

Fort Ontario, Oswego, New York, in charge of Lieutenant Colonel C. E. Blunt, brevet colonel United States army.—The principal operations of the year have been the raising of the scarp on all the fronts (omitting the unfinished flanks) to within two and a half feet (average) of its final height.

The masonry of the two stone guard-houses flanking the sallyport has been completed. All the roof surfaces on front No. 4 have been finished and covered with mastic, and the parapet of the curtain and flanks mainly embanked.

The stone used is quarried on the public land.

During the coming year it is proposed to complete the scarp of faces and curtains, and part of the flanks.

Appropriation asked for the next fiscal year, $50,000.

Fort Montgomery, outlet of Lake Champlain, New York, in charge of Lieutenant Colonel C. E. Blunt, brevet colonel United States army, and Captain J. W. Barlow, brevet lieutenant colonel United States army.—The principal operations at this work have been the completion of the flagging of the first and second stories of bastions C and D; raising the south end of the parade wall of curtain III, and the staircase in bastion C, to reference (30.80′); turning the lower passage arches in bastion C, and the second story arches of curtain III; advancing the interior finish of the officers' quarters, and constructing the revetment wall of coverface.

During the present year it is proposed to complete the staircase in bastion C, the parade wall of curtain III, and the revetment wall of coverface.

Appropriation asked for the next fiscal year, $25,000.

Fort Knox, Bucksport, Penobscot river, Maine, in charge of Major T. L. Casey, brevet colonel United States army, and Lieutenant Colonel George Thom, brevet brigadier general United States army.—Operations on this work, owing to the limited amount of the appropriation available therefor, were discontinued about the middle of October last, and consisted in completing the masonry and subdrainage of the storage casemates under the parade of the main work, and digging a trench behind the rear wall a part of the distance to receive a conduit for the roof drainage; completing the banquette steps of the north counterscarp gallery; placing the pintles and traverse irons upon seven front pintle platforms of the north covered way and on two flanking positions in the northeast demi-bastion; mounting guns on batteries A and B; finishing officers' quarters; finishing parapets and terrepleins of 15-inch guns; and in repairs of slopes, roads, and drainage of the work.

Appropriation asked for the next fiscal year, $25,000.

Fort Popham, mouth of Kennebec river, Maine, in charge of Major Thomas L. Casey, brevet colonel United States army, and Lieutenant Colonel George Thom, brevet brigadier general United States army.—Active operations were carried on from July 1st to the end of October, 1867. The arches

of the gun casemates, Nos. 24 to 37 inclusive, on the water-fronts were covered with concrete, the roof surfaces formed and covered with mastic, and the mastic covered with brick flatting, except where the valley arches are to be constructed. The concrete floors of the three magazines on terreplein of water-fronts were laid, and the side walls brought up to the level of roof surfaces. In the scarp 386 running feet of the course immediately under the cordon were laid, completing that course except on the gorge, and bringing the water-fronts and outer faces of the bastions up to reference (45′.)

Appropriation asked for next fiscal year, $50,000.

Fort Gorges, Portland Harbor, Maine, in charge of Major Thomas L. Casey, brevet colonel United States army, and Lieutenant Colonel George Thom, brevet brigadier general United States army.—The progress made during the year is as follows: The rubble foundations, 15 feet in depth, for two of the stairway towers have been completed; the cut stone masonry of tower No. 1, (in angle I-II) has been carried up 24½ feet; that of tower No. 3, (in angle III-IV) six feet; and that of tower No. 4, (in angle IV-V) 20 feet, being now built up to reference (47′.)

The scarps of the magazines have all been reinforced, and their brick linings completed. The ante-rooms have been finished and fitted up for ordnance store-rooms.

Three barbette center pintle gun platforms have been built.

The two magazine traverses on the gorge, and four bomb proof traverses, have been built and partially covered with concrete.

The quarters in the gorge have nearly all been lathed and plastered, all the windows and outer doors glazed and put in, and some of the rooms nearly completed.

Appropriation asked for the next fiscal year, $25,000.

New Fort Preble, Portland Harbor, Maine, in charge of Major Thomas L. Casey, brevet colonel United States army, and Lieutenant Colonel George Thom, brevet brigadier general United States army.—The progress made during the year is as follows: The scarps B and C of old enclosed work have been carried from reference (16′) and scarp A from its foundations in reference (11′8″) to completion in reference (32′;) the earthern parapet on front C has been carried to reference (40′) for about two-thirds of the length of this front; and the remainder of this front, and fronts B and A, have been covered with earth to reference (36′) to protect them through the winter.

The stairway from the upper to the lower parade, south flank, has been carried from reference (11′ 8″) to reference (28′,) which completes the steps as well as the masonry between it and the old enclosed work.

In the magazine traverse of the south battery excavation has been made for its foundation and drainage through the parapet; the drains built; concrete foundation laid; and the masonry built as follows: The cut stone masonry on the east side and front carried to reference (33′;) the brick work in the entrance up to reference (32′;) and in the anteroom and west side of magazine to reference (31′.)

The two piers on front II next to angle II-III have been carried up to reference (12′;) the remaining pier, and the magazine foundation at the angle I-II, have been carried up to reference (6′ 6″.)

In the old enclosed work the brick buildings heretofore used as officers' quarters, and the two small magazines in it, have been taken down, preparatory to building a new magazine.

Appropriation asked for the next fiscal year, $50,000.

Fort Scammel, Portland Harbor, Maine, in charge of Major Thomas L. Casey, brevet colonel United States army, and Lieutenant Colonel George

Thom, brevet brigadier general United States army.—The progress made during the year is as follows: The gorge wall of east bastion has been carried from reference (56′ 8″) to reference (59′ 9″;) and the two magazines and gorge scarp also to reference (59′ 9″;) the flagging of the second tier of the gorge laid, and ante-rooms in the gorge of this bastion finished.

The gorge parade wall of the west bastion, together with its two magazines and ante-rooms, have been carried from reference (41′) to reference (59′ 9″;) and the gorge scarp wall in rear, from reference (55′ 3″) to reference (59′ 9″) and all the flagging laid on the second tier of the gorge. The magazines and ante-rooms of the bastion have been finished.

Excavation has been made for the foundation of magazine traverse C of the main work, its parade wall carried up to reference (56′,) and its other walls to reference (58′ 9″.)

Partial excavation has been made for magazine traverse B.

Appropriation asked for the next fiscal year, $50,000.

Fort McClary, Portsmouth Harbor, Kittery Point, Maine, in charge of Lieutenant Colonel J. G. Foster, brevet major general United States army.—At this fort the work accomplished in the past fiscal year comprises the completion of the excavation of the solid rock to the required dimensions to form the ditches of the north and west (land) fronts, and for cisterns, magazines, covered passages to the caponnieres, and cunettes to the ditches; the construction of one hundred and sixty-two feet of granite masonry scarps of the west fronts, and of the entire length of granite scarp of the north front to the height of nine courses, or twenty feet four inches to the reference (59′;) the construction of the granite masonry scarp of the northwest caponniere, including four embrasures complete to a height of four courses or eleven feet two inches, to the reference (50′ 10″;) the construction in this caponniere of a brick cistern, and granite masonry magazine, with brick covering arches and a portion of the granite masonry side walls of the passage leading to the terreplein; the extension of the granite scarp of the south front across the south end of the west ditch; the filling with dry rock the south end of this ditch to the requisite grade, and the dry rock filling behind the scarp walls and in the glacis.

This year it is proposed to continue the work on the land fronts.

Appropriation asked for the next fiscal year, $75,000.

Fort Constitution, Portsmouth harbor, New Hampshire, in charge of Lieutenant Colonel J. G. Foster, brevet major general United States army.—At this fort during the year no work except the guarding and preservation of machinery and material has been done.

A large supply of materials and ample machinery are ready for active operations.

No appropriation asked for the next fiscal year.

Fort Warren, Boston harbor, Massachusetts, in charge of Colonel H. W. Benham, brevet major general United States army.—The work for the past year has consisted mainly in building one bomb proof traverse on the coverface of the northeast front (No. 2) and the construction of another almost to completion on the same coverface. The building up of the scarp wall and arch of the main gateway, with some repairs of drains, slopes, &c., and the removal of the old engineer buildings within the fort, and their reconstruction nearly to completion on the exterior of the work.

During the present year it is proposed to continue the construction of bomb proof traverses around the parapet of main work, complete the engineer buildings outside the fort, repair embankments and slopes, and stop the leaks over the arches of some of the principal casemates.

Appropriation asked for the next fiscal year, $100,000.

Fort Winthrop, Boston harbor, Massachusetts, in charge of Colonel H. W. Benham, brevet major general United States army.—The work of the year has consisted mainly in the construction of the long covered way which forms a large arched communication between the tower ditch and south battery; the raising of the embankment up to the height of the proposed terreplein of the bastions at the northeast, northwest, and southwest angles of the proposed earthwork around the tower; the repair of the embankments of several of the bomb proof traverses at the different batteries, and the receiving and preparation of the material necessary for constructing the open covered way from the south battery to the water batteries.

The operations proposed for the present year are the construction of a wall for the protection of the face of the bluff in front of the east battery, the continuation of the embankment of the earthwork surrounding the tower, and the construction of the open covered way from the south to the water batteries.

Appropriation asked for the next fiscal year, $75,000.

Fort Independence, Boston harbor, Massachusetts, in charge of Colonel H. W. Benham, brevet major general United States army.—The work of the past fiscal year comprises the completion of the masonry, concrete, and earth covering of the magazines of the northwest exterior battery, the commencement and essential completion of the masonry of the large bomb proof traverse of the southeast exterior battery, and the commencement of the masonry of the adjacent magazine, the cutting down of the parapet, and the enlargement and raising of the embankment at the outer extremity of this battery to the level of the terreplein for the central front pintle guns there, and the preparation of the stone required for the gun platforms and magazines.

It is proposed during the present year to commence the construction of the new sea-wall, complete the traverse and magazine of southeast battery, and repair the slopes of the northwest battery.

Appropriation asked for the next fiscal year, $50,000.

Permanent forts at Provincetown harbor, Massachusetts.—Commencement of operations here are waiting for the preparation of plans for the works.

No appropriation asked for the next fiscal year.

Fort at Clark's Point, New Bedford, Massachusetts, in charge of Captain J. A. Smith, brevet major United States army.—The scarp and parade walls have been completed, also the concreting of roofs over arches.

All the foundations for breast height wall and gun platforms have been raised to the height for receiving the stone superstructures.

The mastic covering of roofs is far advanced, and all the valley arches with their manholes and covers completed.

The masonry for three magazines has been built. The masonry of two stair towers on gorge has been completed, and the towers furnished with iron stairways.

The balcony forming communication with second tier of quarters has been completed, and two casemates for quarters have been furred with brick.

The iron work for upper balcony has been made, and the balcony nearly finished. Two magazines have been completed and made ready to receive powder. Four heavy doors have been made for magazines, also all the hinges for outer doors, and several doors fitted and hung.

It is proposed during the year ending June 30, 1869, to cover the mastic roofing with bricks, gravel, and earth, and to complete as far as possible with available funds the construction of parapet and terreplein and covering for magazines.

The work has now arrived so near completion that it is highly important it should progress continuously until finished.

The amount estimated to complete the work, exclusive of additional batteries, for which plans have been prepared, is fifty thousand dollars.

Appropriation asked for the next fiscal year, $50,000.

Fort Adams, Newport harbor, Rhode Island, in charge of Major D. C. Houston, brevet colonel United States army.—The work on this fort has consisted in removal and repairs of barn, repairs of permanent wharf, construction of new postern gates, putting up iron railing about terreplein stairway, construction of water-closets for enlisted men, building guard-house, repairing sidewalks, coping and surface drains, repairing casemate arches and terreplein to prevent leakage, refacing brick embrasures, repointing parade wall, repairing slopes of main work and of redoubt.

The work contemplated for the year ending June 30, 1869, will consist in repairs of permanent wharf; repairs of sea-wall protecting embankment of glacis west of fort; repointing parade wall of main work and the redoubt; continuing repairs of brick embrasures, main work.

No appropriation asked for the next fiscal year.

Defences of Dutch island, Rhode Island, western entrance Narragansett bay, in charge of Major D. C. Houston, brevet colonel United States army.—Operations at this point during the past year have consisted in altering the upper battery to adapt it to an armament of 15-inch guns; constructing a permanent wharf; moving and repairing building for overseer's quarters; preparing site for proposed permanent work on summit of the island; removing and repairing buildings used as mess-house and stable, and making roads.

The operations contemplated for the year ending June 30, 1869, are completing the work above enumerated, and commencing work on the permanent defences.

No appropriation asked for the next fiscal year.

Fort Schuyler, East river, New York, in charge of Major H. L. Abbot, brevet brigadier general United States army.—The operations during the past year have been confined to completing two service magazines; laying two 15-inch gun platforms upon the coverface; making necessary modifications of the casemates of the lower tier of the main work, to adapt them to receive the new iron carriages of the 10-inch guns; and to making necessary repairs upon the wharf, engineer buildings, &c., and a survey of the public lands.

The operations proposed for the fiscal year ending June 30, 1869, are the following: Completing the work now on hand, constructing magazine in place of arms, extending sea-wall and repairing wharf.

Appropriation asked for the next fiscal year, $50,000.

Fort at Willet's Point, eastern entrance to New York harbor, in charge of Lieutenant Colonel James C. Duane, brevet brigadier general United States army.—At this work during the year the arch over the service magazine in the second tier of the channel bastion, the drain gallery in the rear of the northeast retaining wall, the guard-house, and the quarters for engineer in charge, were finished. The arches over the salient casemate and two flank casemates in the channel bastion, and the cloister arch connecting the flank casemates with the service magazine, were constructed, and excavation for a storage magazine commenced.

It is contemplated for the present year, to continue the excavation for the storage magazine as far as the funds will allow.

Appropriation asked for the next fiscal year, $50,000.

Fort Columbus, Governor's island, New York harbor, in charge of Major

N. Bowen, brevet colonel United States army.—The operations of the year at this work consisted in pointing the scarp; relaying with new flagging the area under the portico of barracks; taking up and repairing the drains near magazine; cutting man-holes in flagging of sidewalk; repairing roads, slopes, glacis and grass plots in parade, and other slight repairs.

For the coming fiscal year it is proposed to renovate the system of drains and cunettes for the island; repair coping; make a new floor of mastic and brick concrete for cellar vault; reline and refloor magazines; make new draw-bridge and portcullis; continue unfinished repairs, and make any others that may become necessary for the preservation of the work.

Appropriation asked for the next fiscal year, $15,000.

Castle Williams, Governor's island, New York harbor, in charge of Major N. Bowen, brevet colonel United States army.—The galleries, doors, and embrasure shutters of the casemates have been repaired. Ten casemates have been repaved with bricks, and the iron traverse rails repaired.

The seams of the mastic covering of terreplien have been calked with oakum and pitch.

A new iron gutter has been put up around the parade wall on the terreplein of barbette.

During the present fiscal year it is proposed to repair and partly refloor the galleries and the upper tiers of casemates, and renew the heavy girders there; reline and refloor the magazines; and make any other repairs that may become necessary.

Appropriation asked for the next fiscal year, $10,000.

South battery, Governor's island, New York harbor, in charge of Major N. Bowen, brevet colonel United States army.—In the parade the flagging has been taken up and relaid; the walks in front of magazine taken up and new flagging laid; the stone and mason work of well repaired. The pavement in the sallyport has been taken up, dressed, and relaid, and the drains have been opened and repaired.

During the present fiscal year it is proposed to point masonry, repair the coping, and reline and refloor magazines.

Appropriation asked for the next fiscal year, $5,000.

Fort Wood, Bedloe's island, New York harbor, in charge of Major N. Bowen, brevet colonel United States army.—During the year the exterior walls and coping of the magazines, the coping of the parade wall, the mason work of the steps and posterns, and the brick work of barracks, have been pointed. The draw-bridge and its railing have been repaired. The sea-wall has been repaired, and the slopes have been repaired and resodded.

For the present fiscal year it is proposed to point masonry, repave posterns, repair coping, reline and refloor magazines, repair slopes, and reinforce gun platforms.

Appropriation asked for the next fiscal year, $60,000.

New battery, near Fort Hamilton, New York harbor, in charge of Lieutenant Colonel John Newton, brevet major general United States army.—At this work during the year one traverse magazine has been lengthened to 25 feet, and five, each 25 feet long, have been nearly completed. The north and south magazines are now completed, except the entrances and a short drain for the latter.

No appropriation asked for the next fiscal year.

Fort Hamilton, New York harbor, in charge of Lieutenant Colonel John Newton, brevet major general United States army.—During the year over 2,000 feet of drainwork have been completed. A portion of the counter-

scarp wall was taken down and partially rebuilt, and other labor expended in pointing walls, constructing and hanging doors, moving and repairing carpenter shop, and storehouse, &c.

No appropriation asked for the next fiscal year.

Fort Lafayette, New York harbor, in charge of Lieutenant Colonel John Newton, brevet major general United States army.—A small sum derived from contingencies of fortifications was devoted to boring upon the proposed site of the new work.

The terreplein, where not covered with a shed, leaks badly, and should at once be repaired in a temporary manner to prevent decay of the wooden gun platforms and casemates.

No appropriation asked for the next fiscal year.

Fort on site of Fort Tompkins, New York harbor, in charge of Major Q. A. Gillmore, brevet major general United States army.—During the past year operations have been confined to those necessary to complete the construction of the south soldiers' latrine, and the drain appertaining to it on the slope in front of the south side of the wing, and also the making of roads, care and preservation of slopes, repairs thereto, &c.

The work for the ensuing fiscal year will be the excavation of the parade of the fort, and the preservation of the slopes, drains, roads, &c.

Appropriation asked for the next fiscal year, $80,000.

Battery Hudson, New York harbor, in charge of Major Q. A. Gillmore, brevet major general United States army.—No work has been applied to this battery during the last fiscal year beyond such as was incidental to keeping it in order, such as cleaning out drains and traps, cutting the grass, &c.

The operations for the current fiscal year will be confined to repairs upon the storage magazine, which leaks, and in the preservation of the work.

No appropriation asked for the next fiscal year.

New casemated battery on Staten island, New York harbor, in charge of Major Q. A. Gillmore, brevet major general United States army.—The stone cutting for the foundation courses was continued during July and August, 1867, and was then suspended for more pressing work.

Preliminary operations for the construction of a stone wharf, in place of the wooden one at present existing, were commenced in May, 1868, and continued to the end of the fiscal year. These consisted in preparing the road leading to the dock, and cutting stone for the wharf from granite stock on hand.

Operations for the ensuing fiscal year will be directed to the construction of the stone wharf above mentioned.

No appropriation is asked for the next fiscal year.

North cliff battery, Staten island, New York harbor, in charge of Major Q. A. Gillmore, brevet major general United States army.—The operations of the past year are comprised in the construction and completion of the principal magazine, the filling above it, and the filling of the parade in the south end. The magazine is complete, with the exception of hanging the doors. The parados has been filled up nearly to the level of the foundation of the bomb-proof and magazine, in reference (22′.)

The operations for the ensuing year will be directed merely to finishing the filling above the magazine, sodding and completing the slopes in rear of the battery, and, if the means on hand will justify it, in laying the foundation and a portion of the rubble wall of the bomb-proof and magazines in the parados.

No appropriation asked for the next fiscal year.

South cliff battery, Staten island, New York harbor, in charge of Major

Q. A. Gillmore, brevet major general United States army.—The operations on this work have been confined to excavating for and macadamizing the roads from the south end of the battery to the rear of Battery Hudson, and from the north end to Fort Wadsworth; paving the gutters of these roads, and resodding portions of the slope resting thereon.

The operations of the current fiscal year will be merely to preserve and keep in order the battery.

No appropriation asked for the next fiscal year.

Fort at Sandy Hook, New Jersey, in charge of Lieutenant Colonel John Newton, brevet major general United States army.—The condition of the channel fronts remains as at the date of the last annual report.

The southeast, south, and southwest land fronts have been advanced during the present year. The scarp of the southeast front is generally at the reference of the sills of the loop-holes; of the southwest, at the reference of two courses below the sills; and the short (south) front has about half the foundations and a small portion of the scarp built to the reference, (7′.)

The work on the land fronts, which is entirely independent of modifications of the channel fronts, should not be delayed, and the largest sum that could be conveniently expended in a year might with propriety be appropriated.

Shore improvements for protection of site of fort.—Repairs were made to jettees 1, 2, and 4. A new jettee (No. 6) was commenced in September, between jettees 1 and 2, with the object of protecting the root of the latter from the action of the seas, tending to separate the jettee from the land. To fulfil this purpose, No. 6 requires considerable more development.

The jettees, being composed generally of small masses, are liable to have portions removed by the waves during storms, and to remedy this it would be necessary to protect their heads by large blocks of concrete of from five to fifteen tons weight.

These constructions being short, are, for that reason, and especially during stormy periods, exposed to be cut around by the water, and hence require, from time to time, to be extended into the land. A continual watch will be necessary, at least for some time, against this danger.

The object has been during the past season to do only what was absolutely necessary for preservation of existing works of protection, and jettee No. 6 was commenced, and should be extended for this purpose.

Appropriation asked for the next fiscal year, $150,000.

Fort Mifflin, Delaware river, Pennsylvania, in charge of Lieutenant Colonel C. S. Stewart.—Extensive repairs have been made in the embankments of main magazine. Its ventilators have been in part rebuilt, and copper caps placed thereon.

Over four thousand cubic yards of deposit have been removed from the ditches. The wharf, river wall, sluice, and parapets have been repaired, and much miscellaneous work done.

Contemplated operations.—Removal of old traverse stones and completion of gun-platforms; probable construction of bomb-proof traverse, &c.; pointing of scarp and breast-height walls; grading of terrepleins and banquettes after the gun-platforms are modified, and renewal of roadway of bridges.

Appropriation asked for the next fiscal year, $35,000.

Fort Delaware, Delaware river, Delaware, in charge of Lieutenant Colonel C. S. Stewart.—The southern dock wall has been extended for 69 feet, and the northern 220 feet; the two sluice-ways to island ditches have

been finished; the coping of all the fronts, and portions of scarp wall have been pointed; flagging has been relaid along the parade wall of fronts 1 and 2; the island ditch has been extended 243 feet to the sluiceway; the island embankment, for the length of 3,700 feet, has been repaired and raised to the proper level, and the engineer quarters have been repaired and painted.

Appropriation asked for the next fiscal year, $70,000.

New fort, opposite Fort Delaware.—Commencement of operations is deferred until the project for the work is revised.

No appropriation asked for the next fiscal year.

New fort, near Delaware breakwater.—This work will be begun as soon as the best methods of applying iron to such constructions are determined on.

No appropriation asked for the next fiscal year.

Fort McHenry, Baltimore harbor, Maryland, in charge of Major William P. Craighill, brevet lieutenant colonel United States army, Major J. G. Parke, brevet major general United States army, and Colonel J. H. Simpson, brevet brigadier general United States army.—During the year the new work of parapets of water battery and magazine covering have been consolidated; glacis of water battery re-formed; new drains cut for magazines, &c.; interior slope of main work re-formed of sod, and brick pavement laid connecting the fort and the officers' quarters with outer gateway.

The whole improvement of water battery, as contemplated, is now completed, except covering terreplein of water battery and ditch of main work with powdered slag and cinders.

No appropriation asked for the next fiscal year.

Fort Carroll, Baltimore harbor, Maryland, in charge of Major William P. Craighill, brevet lieutenant colonel United States army, Major J. G. Parke, brevet major general United States army, and Colonel J. H. Simpson, brevet brigadier general United States army.—The work is now completed on fronts 1, 2, 3, 4, and 5, up to springing line of casemate arches of second tier.

No appropriation asked for the next fiscal year,

Obstructions of the Potomac.—Sufficient *materiel* has been provided to enable experiments to be made to test the suitableness of the designs adopted for such obstructions. It is proposed to subject the obstructions to the requisite trials as to the facility of handling, placing, and maintaining them in channel ways, and of their sufficiency to impede and resist the passage of hostile ships. Some naval co-operation is desirable in the execution of the trials, which will be entered upon as soon as practicable.

No appropriation asked for the next fiscal year.

Fort Monroe, Old Point Comfort, Virginia, in charge of Colonel Henry Brewerton, brevet brigadier general United States army.—During the past year some repairs have been made to the floors and embrasures of casemates; the terreplein and slopes and ramps of the work have been thoroughly repaired; the roadway inside of the fort has been graded and covered with six inches of clay and sand; 761 running feet of drains have been dug on each side of the road; the decayed wooden platforms on the land fronts have been removed, and the ditch has been thoroughly cleaned on all the fronts of the work.

In the water battery and covered way the arches of eight casemates have been partially uncovered, a portion of the brick work removed, and the roof repaired. The sand in front of the battery has been removed, and the ground graded, and some slight repairs made.

In the redoubt 490 feet of the wooden breast height have been repaired or rebuilt. The decayed wooden gun platforms have been taked up. The slopes have been repaired and sodded. A stone wall 80 feet in length has been built to support the foot of the glacis opposite the curtain of front 1. A wagon road leading to the beach has been constructed. A breakwater has been built on the beach opposite front 2, and the railroad and wharf have been repaired.

It is proposed this year to widen the terreplein and increase the thickness of the parapets of the channel fronts of the main work, lay down new platforms for heavy guns, construct traverses and service magazines, and remodel and finish the redoubt.

Appropriation asked for the next fiscal year, $100,000.

Artesian well, Fort Monroe, Virginia, in charge of Colonel Henry Brewerton, brevet brigadier general United States army.—Operations, preparatory to sinking the 8-inch tube within the 12-inch pipe of the well of 1864 and 1865, were commenced in August, 1867. It was considered best to withdraw the 5-inch and 8-inch pipes from the well of 1845, with a view of using the latter sized pipes in the well now in progress.

One hundred and eighty-six feet of the 5-inch pipe and 120 feet of the 8-inch pipe have been withdrawn. A house was constructed over the site of the new well, and a steam engine and necessary machinery for boring were put up.

The work has steadily progressed under difficulties which have been surmounted, and now reaches to a depth of 370 feet, being 30 feet greater than has been before reached at this locality.

It is proposed this year to apply the balance of available means in sinking the 8-inch pipe within the 12-inch pipe until pure water is reached.

No appropriation is asked for the next fiscal year.

Fort Wool, Hampton Roads, Virginia, in charge of Colonel Henry Brewerton, brevet brigadier general United States army.—Operations have been confined to the construction of magazines of the first tier. The loadings on the sites of the magazines at the capital, and at the east and west ends, have all been removed, and the material placed as loadings on the sites of the proposed traverse magazine and main magazines at the gorge of the work. The foundations of the magazines at the capital and at the west end have been finished, and excavations made preparatory to commencing the foundation of the magazine at east end. The first, second, and third courses of the superstructure of the magazine at the capital, including filling rooms, stairways, &c., have been completed, and a portion of the fourth course has been built.

It is proposed to expend the amount available in the completion of the magazine and adjuncts of the first tier at the capital, and in the construction of the magazines, &c., of the same tier at the east and west ends, and on such other portions of the work as may hereafter be decided upon.

No appropriation asked for the next fiscal year.

Fort Clinch, Amelia island, Florida, in charge of Captain J. W. Barlow, brevet lieutenant colonel United States army.—Active operations were continued upon this work until October, 1867, during which period the main sewer was completed, the drawbridge gateway nearly finished, storehouse and barrack covered, interior finish of storehouse continued, and the masonry of those gun platforms which had been commenced entirely perfected. Work was then suspended, and the fort left in charge of a keeper, who, with the assistance of some additional hired help, has kept the various parts of the work in good order throughout the remainder of the season.

Appropriation asked for the next fiscal year, $50,000.

Fort Taylor, Key West, Florida, in charge of Major Walter McFarland and Colonel J. H. Simpson, brevet brigadier general United States army.—The operations of the year consisted in the filling in of the southern end of the coverface, up to the required reference, with sand; the completion of one-half of the permanent sea-wall of the northern front; the filling in of a portion of this end with sand; the excavation of one-half of the ditch by the dredging machine, and the continuation of the embankment of glacis of tower 1.

The appropriations having been exhausted, no operations can be carried on during the present fiscal year.

Appropriation asked for the next fiscal year, $150,000.

Fort Jefferson, Garden Key, Tortugas, Florida, in charge of Major Walter McFarland and Colonel J. H. Simpson, brevet brigadier general United States army.—Officers' quarters, front piazza completed, except roofing with galvanized iron; one section of nine rooms finished completely; six other rooms completed, except partitions of the folding doors; and about one-half of the remaining rooms furred, lathed, &c.

Soldier's barracks.—One section furred and lathed, and its window frames put up.

Ditch on face three excavated.

The operations contemplated for the present fiscal year are the excavation of the ditch on face four, and the covering of roof of soldiers' barracks, and of piazza of officers' quarters, with galvanized iron.

Appropriation asked for the next fiscal year, $100,000.

New fort at Tortugas, Florida.—This work will be commenced as soon as the best combination of materials for its uncovered scarps is determined on.

No appropriation asked for the next fiscal year.

Fort Pickens, Pensacola harbor, Florida, in charge of Major M. D. McAlester, brevet brigadier general United States army, and Major Frederick E. Prime, brevet colonel United States army.—The operations of the past year have consisted in rebuilding the wharf; opening and cleaning the drain of ditch; building plank road from wharf to entrance of fort; repairing pavement of terreplein; removing sand and traverses in south bastion, and uncovering casemate arches of southwest bastion for foundation of 15-inch gun platform.

The operations contemplated for the present fiscal year are the construction of 15-inch gun platforms in southwest and northwest bastions; building wooden platforms for projectiles, and such general repairs as may be necessary.

No appropriation asked for the next fiscal year.

Fort Barrancas and redoubt, Pensacola harbor, Florida, in charge of Major M. D. McAlester, brevet brigadier general United States army, and Major Frederick E. Prime, brevet colonel United States army.—During the past year the breast-height walls of the main work and of the redoubt have been repaired, and the parapets regraded and sodded; the necessary repairs of foundation of southwest angle of counterscarp wall made; the southern extremity of glacis and ditch graded and sodded, and west branch of ditch regraded; gates of main entrance made and hung, and a fence around the works commenced and about half completed.

It is proposed during the present year to rebuild the permanent part of the bridge; repair the drawbridge machinery; complete the fences; repair the woodwork of magazines, and make some other slight necessary repairs.

No appropriation asked for the next fiscal year.

Fort Morgan, eastern entrance to Mobile bay, Alabama, in charge of Major M. D. McAlester, brevet brigadier general United States army, and Major Frederick E. Prime, brevet colonel United States army.—The operations of the year at this work consisted in repairs to engineer buildings; putting in wooden fronts of casemates for engineer and ordnance storerooms; repairing breakwater and securing its foot by a rip-rap protection; repairing mouth of main drain; grading and sodding slopes; removing walls of old citadel, and commencing the foundation for concrete sea-wall in continuation of present breakwater.

During the present year it is proposed to repair the wharf; continue the demolition of the citadel; continue the grading and sodding of slopes; complete the foundation of sea-wall, and make such general repairs to the work as may be necessary.

No appropriation asked for the next fiscal year.

Fort Gaines, Dauphin island, Mobile bay, Alabama, in charge of Major M. D. McAlester, brevet brigadier general United States army, and Major Frederick E. Prime, brevet colonel United States army.—At this work during the year the repairs of wharf, of temporary buildings occupied by the engineer force, and of the two buildings at the main entrance have been completed. Repairs of plastering, woodwork, and roof surfaces of officers' quarters have been commenced. The earth-cover of scarp of southwest bastion has been removed and the material embanked in glacis.

For protection of the site two wing-dams were built and partly strengthened, and connected with concrete and fragments of masonry from the citadel of Fort Morgan.

Operations for the present year will consist in completing shore protection and repair of buildings in the fort; reopening drainage of ditch and grading same; keeping the shore protection in repair, and extending it if required.

Appropriation asked for the next fiscal year, $50,000.

Fort on Ship island, coast of Mississippi, in charge of Major M. D. McAlester, brevet brigadier general United States army, and Major Frederick E. Prime, brevet colonel United States army.—Nothing has been done to this work during the past year except cutting grass and keeping parapet slopes in good order.

During the present year it is proposed to complete the rooms on each side of the gateway, lay flagging in front of the same, and restore the drainage of the parade.

No appropriation asked for the next fiscal year.

Fort Pike, Rigolets Pass, Louisiana, in charge of Major M. D. McAlester, brevet brigadier general United States army.—No work done here during the year.

It is contemplated to repair the pile revetment protecting the site, repair the bridges, and make such other repairs as may become necessary during the current fiscal year.

No appropriation asked for the next fiscal year.

Fort Macomb, Chef Menteur Pass, Louisiana, in charge of Major M. D. McAlester, brevet brigadier general United States army.—This work is in serviceable condition, including its magazines and platforms, excepting three wooden platforms and the two bridges crossing the inner and outer ditches.

No work has been done the past year.

It is contemplated to repair the bridges, and effect such other repairs as may become necessary during the present fiscal year.

No appropriation asked for the next fiscal year.

airs.
o appropriation asked for the next fiscal year.
ort Jackson, Mississippi river, Louisiana, in charge of M. D. McAlester, el brigadier general United States army.—This work is in a condition the service of its armament.
uring the past year the levees around the work were put in thorough air, and some slight repairs to the work itself were made.
he erection of a storage magazine and the execution of the current airs are the operations contemplated for the present year.
ppropriation asked for the next fiscal year, $75,000.
ort St. Philip, Mississippi river, Louisiana, in charge of Major M. D. Alester, brevet brigadier general United States army.—This work is in d condition.
ll the levees for protection from overflow have been repaired. The on revetment of levee on the river front has been replaced, and the re embankment raised to the level of the wharf. A new levee has n run from the lower end of the front levee to the bayou.
uring the present year it is contemplated to build a storage maga-, with service magazines in connection therewith; to modify and air the service magazine in the upper battery, and to make such or repairs as may be necessary.
ppropriation asked for the next fiscal year, $75,000.
ort Livingston, Barataria bay, Louisiana, in charge of Major M. D. Alester, brevet brigadier general United States army.—No operations e taken place at this work during the year.
is contemplated to prepare platforms for several guns of large cali- to modify the counterscap casemates; to repair the breakwater, and ake some slight general repairs to the work.
ppropriation asked for the next fiscal year, $24,500.
ort at Fort Point, entrance to San Francisco harbor, California, in ge of Major George H. Elliot.—The railroad from the wharf to the sea wall has been completed. The coping of the old wall has been nded 126 feet. The heavy coffer-dam for the protection of the site ie new sea wall during its construction was finished early in the .
he excavation for the sea wall has been completed, and 228 feet of latter has been carried to reference (10′,) 174 feet to reference (6′6″,)

100 feet towards the latter, and the roadway has been raised and repaired.

Large stones have been placed in front of a part of the old sea wall to protect the concrete foundation, which is exposed to the sea.

Necessary repairs have been made in the main work.

Probable operations for the fiscal year ending June 30, 1869.—The sea wall in front of the 15-inch gun barbette battery on the eastern shore will be finished, and the filling in its rear completed.

Appropriation asked for the next fiscal year, $200,000.

Fort at Lime Point, San Francisco harbor, California, in charge of Major George H. Mendell, brevet colonel United States army.—During the past year the following works have been completed:

Lodging and mess-house with outbuildings, stable, carpenters' shop, office for overseer and master workmen, two sets of quarters for master workmen, blacksmiths' shop with four forges, water tank, storehouse, coal sheds, brick powder magazine, and small tank.

Water has been brought about 400 yards in pipes, and arrangements made to throw a stream over the buildings most exposed to fire. One mile of fencing has been built, and 1,000 yards of roadway mainly in excavation through hard rock. A crib wharf has been constructed; a steamboat built for the service of the work, and rock excavation of site made to the extent of about 60,000 yards.

A tunnel has been excavated for a distance of about 60 feet for a large blast. The tunnel, when completed, with its branches, will be about 200 feet in length. The charges, four in number, in the aggregate will amount to about nine tons of powder. During the present year the rock excavations will be continued and probably completed, and operations on the scarp of the work commenced.

Appropriation asked for the next fiscal year, $200,000.

Fort at Alcatraz island, San Francisco harbor, California, in charge of Major George H. Mendell, brevet colonel United States army.—The operations on this work during the past fiscal year have been limited, and have been mainly directed to the following objects, viz.:

The wharf was extended, on wooden piles, for a distance of 50 feet; a wharf crane, capable of hoisting a weight of 10 tons, was constructed; a number of permanent centre pintle platforms were adapted for 8-inch and 10-inch guns and iron carriages by replacing the pintles and traverse circles; the masonry of the rear rooms of the casemated barrack was carried up to its full height; the floor of the first tier of casemates was excavated in rock and prepared for a pavement of asphaltum; the plumbing of the water-closets in this barrack was completed, and additional water-pipes in the casemat es were placed; the stone steps from the second tier of casemates to the barbette were cut and laid, and all the coping for the area wall was cut with the exception of two stones.

Appropriation asked for the next fiscal year, $100,000.

Defences at the mouth of the Columbia river, Oregon, in charge of Major George H. Mendell, brevet colonel United States army.—It is proposed during the present year to remove the decayed wooden revetment of the scarp of Fort Stevens, and carry the exterior slope of the parapet to the bottom of the ditch.

No appropriation asked for the next fiscal year.

Survey for land defences at San Francisco, California, in charge of Major George H. Elliot.—The survey for these defences was commenced in March, 1867, with the aid of a party of the coast survey, and the field work was finished in October of the same year. The final report and maps have not yet been received.

No appropriation asked for the next fiscal year.

BATTALION OF ENGINEERS AND DEPOTS.

Battalion of engineers commanded by Major Henry L. Abbot, brevet brigadier general United States army, headquarters Willet's Point, New York.—The strength of the five companies of engineer troops on the 30th of June, 1868, was 21 officers and 667 enlisted men. Eighty-five recruits were needed to complete the organization. The companies of the battalion were stationed and commanded as follows:

At Willet's Point, New York harbor, company A, Captain A. Stickney, brevet major United States army, company B, Captain A. H. Burnham, brevet major United States army, company C, Captain A. H. Holgate; at Jefferson barracks, Missouri, company E, Captain J. W. Cuyler; at Yerba Buena island, California, company D, Captain S. M. Mansfield, brevet lieutenant colonel United States army. A detachment of 50 men from companies A, B, C, and E, under the command of Captain A. N. Damrell, brevet major United States army, served at the United States Military Academy for the purpose of aiding in the instruction in practical engineering. During the year also small detachments of enlisted men from the battalion have, from time to time, been furnished for duty with various officers serving upon the staffs of generals commanding in the western military divisions and departments.

The troops at their several posts have been actively employed with the theoretical and practical instructions and drills peculiar to their arm of service, with the storage, classification and repairs of engineer equipage, and with the construction and repairs of the quarters and storehouses of the several posts and depots.

Under the commander of the battalion a system of theoretical and practical instruction for the various commands has been established, and a field observatory erected and supplied with instruments, at Willet's Point. In compliance with General Orders No. 56, dated Adjutant General's Office, Washington, August 1, 1866, schools have been opened for the enlisted men, which would have proved even more successful had a small appropriation been available for the purchase of text-books for the pupils. An appropriation of $200 is recommended for this purpose.

I beg leave to renew the recommendations contained in my report of last year, that a commissary sergeant and two principal musicians should be allowed to the non-commissioned staff of the battalion; that the 7th section of the act of July 13, 1866, taking from engineer soldiers the per diem paid to other soldiers when engaged in continuous labor, should be repealed, and that an appropriation of $1,000 should be made to purchase the stock out of which siege and trench materials are fabricated, for the instruction of the troops at Willet's Point; which recommendations were made the subject of a special communication dated January 9, 1868.

Three points have been selected for engineer posts and depots; namely: Willet's Point, New York harbor, Jefferson barracks, Missouri; and Yerba Buena island, California.

Engineer post and depot of Willet's Point, New York harbor; the post commanded by Lieutenant Colonel J. C. Duane, brevet brigadier general United States army; the depot by Major Henry L. Abbott, brevet brigadier general United States army.—This point, also selected as the headquarters of the battalion of engineers, was constituted an engineer post and depot in 1865, and was the point at which the engineer equipage used (in the Atlantic States) during the late war was concentrated at its close. But one building has thus far been constructed for the storage of the engineer property, namely, a wooden shed 250 feet long by 37 feet in width.

During the past year the storage and classification of the engineer property at this depot has been completed, and limited sales of property have been made to officers of the corps for use upon public works in their charge. The new depot at Yerba Buena, California, has also been supplied from it with the needful trains, tools, &c.

During the past year a portion of the quarters needed for the officers of the command have been erected, a post bake-house and a stable completed, and a post hospital well advanced towards completion.

An appropriation of $15,000 for the barracks at this post, which are much needed, is recommended.

Engineer post and depot at Jefferson barracks, Missouri, until October, 1867, commanded by Captain William Ludlow, brevet major United States army; after that date by Captain P. C. Hains, brevet lieutenant colonel United States army.—Up to the 20th of November, 1867, the depot consisted of a small piece of ground, some two and a half acres and a few temporary wooden buildings wholly inadequate to the storage of the engineer property, or quartering of the troops. At this date the post of Jefferson barracks, with most of its buildings, very much out of repair, and about 300 acres of land, was transferred to the crops of engineers under the operations of General Orders No. 9, dated headquarters military division of the Missouri, October 21, 1867, and the agreement to pay to the quartermasters' department $20,000 for the property.

The property was at once taken possession of by the command, and a general plan for converting the old barracks with the proper quarters and storehouses for the depot was prepared. During the year the alterations of the east portion of the north row of soldiers' barracks for equipment sheds was nearly completed, and some progress made with other portions. The classification and storage of the engineer equipments was well advanced, and some 1,200 yards of fence to enclose the reservation completed.

As by the act of March 2, 1867, but one-half of the sum appropriated for the quarters at Jefferson barracks could be expended, a further appropriation to complete the agreement with the quartermasters' department, of $10,000, is necessary.

For the repairs of the barracks a sum of $15,000 is required. For the construction of four cisterns to hold drinking water for the command, a sum of $1,000 is needed. The appropriation of these several amounts named is recommended.

Engineer post and depot of Yerba Buena island, California, commanded by Captain S. M. Mansfield, brevet lieutenant colonel United States army.—This engineer post and depot was constituted by Special Orders No. 34, dated headquarters of the army, Adjutant General's Office, February 10, 1868, and was occupied by the present command on the 25th of March following.

The island being entirely devoid of buildings, the garrison was encamped, and continued so at the close of the fiscal year.

The command has been actively employed in making roads, clearing and preparing a part of the island for permanent occupation, and in improving the supply of water. A pontoon train and supply of engineer tools were sent from the depot at Willet's Point, and it is expected that the men and materials will be well sheltered before the rainy season commences.

This island forms an admirable position for an engineer depot for the military division of the Pacific. An appropriation of $5,000 is recommended to provide a proper supply of water for the depot.

The above estimate of funds for the repairs of barracks and for fur-

nishing supplies of water, ordinarily enclosed within the estimates of the quartermasters' department, are made in accordance with the decisions of the Secretary of War under date of June 8, 1868.

RIVER AND HARBOR IMPROVEMENTS.

The operations in progress, under the acts making appropriations for the repair, preservation, and completion of certain public works heretofore commenced under the authority of law, &c., approved June 23, 1866, and March 2, 1867, have resulted mainly in securing better facilities for the ingress and egress of the naval and commercial vessels of the United States, rendering navigation safer and more expeditious, although much remains to be done to perfect and complete the plans adopted for improvement.

Previous reports have invited attention to those provisions of the acts making appropriation for the improvement of rivers and harbors, requiring the expenditures to be made by separate contracts for each class of material and each class of labor, with the lowest responsible bidder, after suitable public advertisement, and to the difficulties and vexatious delays incident to this system.

In numerous instances, during the past season, contractors have failed to comply with the terms of their contracts, to the serious injury of the works in progress and subjecting the government to loss.

These cases have been so frequent that it is to be expected many others will occur. Contractors decline to enter into their contracts, after having duly executed them, resulting in a change of contractors before the work has been begun; and, in fact, it has become apparent that there is no certainty that a contract will be complied with unless it should be greatly to the advantage of the contractor. This evil requires the adoption of some uniform mode of procedure in relation thereto, and stringent measures to arrest its progress.

At first instructions were given to the officers in charge of the works at which such failures occurred to award the contracts to the next lowest original bidders, and to notify the delinquents that they would be held accountable for the difference between the amount of their contract and the new one, as well as for any loss to the United States arising from delays caused by their failures; such as the machinery and workmen of other contractors lying idle, &c., &c.

Subsequently, from fears of collusion among the lowest bidders, it was deemed advisable to advertise anew for proposals, at the same time holding the contractor liable for the difference and for losses, should there be any.

In both instances, however, the unavoidable delays in the progress of the work, caused by this change of contractors, have been found injurious, and the experience gained unmistakably proves that it would invariably have been more to the interests of the United States to have authorized the engineer in charge to complete the forfeited contract by the purchase of the material in open market, and the employment of the labor by days' work, holding the delinquent contractor and his sureties liable for any increase of expenditure or other loss to the United States that might arise in thus completing the work contracted for.

It is therefore suggested that in view of the difficulties referred to and to avoid future complications that may arise, authority should be provided by legislation to pursue the course indicated—that is, to purchase in open market, and to employ labor by the day, invariably in all cases of contractors failing to complete their contracts or promptly commencing their engagements.

Experience has, however, proved the system of contracts prescribed in the appropriation acts to be the worst possible mode of carrying on the improvement of rivers and harbors.

The act making the appropriations, section 2, approved March 2, 1867, required a full estimate for the entire and permanent completion of each work, with the amount that may be profitably expended in the next fiscal year.

In compliance therewith, the estimates for continuing the improvements during the year ending June 30, 1869, were submitted, amounting to $6,857,000.

Subsequently these estimates were reduced to $3,436,000, to which sum was added the amount required for certain improvements urgently needed by commerce, and which belonged to the same class of improvements as those for which appropriations had been already made. These additions increased the estimate to $4,012,500. This revision of the original estimates was made in compliance with the resolution of the House of Representatives of March 18, 1868, and the amounts were placed as low as it was deemed prudent, having in view the protection of the improvement from injury and deterioration, together with a reasonable progress towards completion, due regard being had to the wants of commerce in each case.

Moreover these estimates did not embrace other improvements, the information upon which had been called for under resolutions of Congress, but it was not in readiness to be submitted.

These revised estimates formed the basis of the bill which passed the House of Representatives June 30, 1868.

In the act making appropriations and to supply deficiencies, &c., for the year ending June 30, 1868, there is appropriated for the "repairs, preservation, extension, and completion of certain public works on rivers and harbors, to be expended under the direction of the Secretary of War," $1,500,000, with a provision making reference to the bill which passed the House of Representatives June 30, 1868.

This appropriation was, with the sanction of the Secretary of War, distributed to the following named works, regard being had in the allotment to the relative importance of the various improvements, their condition, and the balances of former appropriations on hand applicable to them:

Green Bay harbor	$17,500 00
Manitowoc harbor	17,500 00
Chicago harbor	35,000 00
Michigan City harbor	25,000 00
Aux Becs Scies harbor	10,000 00
Saginaw River harbor	9,000 00
St. Clair flats	86,000 00
Cleveland harbor	17,000 00
Erie harbor	40,000 00
Oswego harbor	20,000 00
Upper Mississippi river	26,000 00
Des Moines rapids	300,000 00
Rock Island rapids	156,000 00
Mississippi river	40,000 00
Missouri river	25,000 00
Arkansas river	20,000 00
Tennessee river, from its mouth to Florence, and from Chattanooga to Decatur, Alabama	85,000 00
Ohio river	85,000 00

Falls of the Ohio	$85,000 00
Mouth of the Mississippi river	50,000 00
Patapsco river	17,000 00
Susquehanna river	5,000 00
Hudson river	85,000 00
Removal of obstructions in East river	85,000 00
Boston harbor	43,000 00
Saco river, Maine	20,000 00
Willamette river	21,000 00
Removal of Blossom Rock, San Francisco harbor	50,000 00

A summary of the operations at each of the localities where surveys and improvements are in progress is herewith submitted, showing the progress during the past year, and containing recommendations for further appropriations with the amounts that can be profitably expended during the next fiscal year upon the works authorized by Congress.

An appendix is also submitted containing the reports of the engineers in charge of the improvements, made in accordance with the following circular and with the requirements of the acts of appropriation, to which attention is respectfully invited for full details of each survey or work of improvement:

[Circular.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., June 10, 1868.

I. Your annual report of progress in all works of river and harbor improvements and surveys in your charge must be transmitted so as to reach these headquarters as soon after the 30th instant as practicable, and should be accompanied by a brief or synopsis of its contents, to be embodied in the report of the Chief of Engineers.

II. Your attention is also invited at the same time to sections 2 and 3 of the act making appropriations for the repair, preservation, and completion of certain public works, &c., approved June 23, 1866, and to section 2 of the act (for the same purpose) of March 2, 1867, with the view of reporting to Congress on the following points, to be embraced in your annual reports, namely:

1. Result of survey or resurvey, with plan adopted, and items of expenditure under that plan.

2. The amount that is required for entire and permanent completion of each work under your charge.

3. The amount that can be profitably expended upon each work during the next fiscal year.

4. The collection district in which each work is located.

5. At or near what port of entry, light-house or fort, each work is located.

6. What amount of revenue was collected at the nearest port of entry to each work, for the last fiscal year.

7. As far as practicable, what amount of commerce and navigation would be benefited by the completion of each particular work.

8. Abstract of proposals for each work, with names of bidders.

9. Abstract of contracts for each work, with names of contractors.

10. Abstract of contracts for each class of materials or labor for each work.

11. A statement of cash received and expended on account of each

work during the fiscal year; also amount of appropriation available June 30, 1868, and amount required for the year ending June 30, 1870.

III. Where the nature of the work is such as not to admit of permanent completion, a plan and estimate should be submitted as to the perpetual annual expenditure required to maintain the harbors and rivers in the condition contemplated in the plan of improvement; or, if the maintenance of the improved condition does not require an annual expenditure, then the probable periods at which the preservation of the works and maintenance of depth of water will require expenditures of money, and the amount of such expenditure.

By command of Brigadier General Humphreys.

THOS. LINCOLN CASEY,
Major of Engineers and Bvt. Col. U. S. A.

HARBORS ON LAKES SUPERIOR AND MICHIGAN.

Officer in charge, Brevet Colonel J. B. Wheeler, major corps of engineers, who has assigned the officers under his orders to the following duties:

Captain A. Mackenzie, corps of engineers, special superintendent for the harbors of Black Lake, Grand Haven, Muskegon, White River, Pentwater, Pere Marquette, Manistee, and Aux Becs Scies; station Milwaukee.

Captain D. P. Heap, corps of engineers, special superintendent for the harbors of Kenosha, Chicago, Michigan City, New Buffalo, St. Joseph, and South Haven; station Chicago.

Assistant Henry Bacon, special superintendent for the harbors of Superior City, Ontonagan, and Eagle Harbor; station Ontonagon.

Assistant W. H. Hearding, special superintendent for the harbors of Marquette, Green Bay, Manitowoc, Sheboygan, Milwaukee, and Racine; station Milwaukee.

Assistant W. T. Casgrain, in charge of surveys and preparation of maps and other duties connected with surveys of harbors; station Milwaukee.

In addition to the officer in special charge a foreman is employed at each harbor to keep a constant watch over government property, and to see that the work is in accordance with the plans and specifications furnished. (See Appendix A.)

LAKE SUPERIOR.

1. *Superior City harbor, Wisconsin.*

The plan adopted for this harbor is to protect the beach on Minnesota Point by an enrockment of rubble-stone, and to narrow gradually the present outlet of the bay to about the width of the river, say 350 feet by crib work, thence to construct two parallel piers; the weather pier (Wisconsin pier) to extend to 18 feet water in the lake. The piers to be built of cribs with grillage bottoms and ballasted with stone.

Estimate for completion	$263,300 00
Amount appropriated	63,000 00
Amount required for completion	200,300 00

During the year 24 cribs have been placed, making 768 running feet of pier work, and more than one half of this has been finished.

During the year there has been received from the Treasury Department on account of this work	$20,000 00
And expended	25,839 72
Leaving due the appropriation	37,026 68

The greater part of this balance will be expended during the present working season. There can be profitably expended during the next fiscal year, if appropriated in time, $100,000. (See Appendix A 1.)

2. *Ontonagon, Michigan.*

The plan adopted for this harbor was given in the last annual report.

Estimate for completion was	$292,801 50
Amount appropriated	97,600 00

During the year 449 running feet of pier work has been built up to the surface of the water. As soon as the cribs have settled well the pier will be finished.

Before close of navigation it is expected that not less than 1,200 feet of pier will be built.

During the year there has been received from the Treasury Department for this work	$35,000 00
There has been expended	30,937 57
And due the appropriation on June 30	66,937 53

Fifty thousand dollars of this amount will be expended during the present working season.

The cost of the entire improvement is estimated by the officer in charge to be	$336,379 23
From which deduct	97,600 00
And this leaves required for completion	238,779 23

If appropriated in time, there could be profitably expended during the next fiscal year, $98,000.

(See Appendix A 2.)

3. *Eagle harbor, Michigan.*

The plan adopted for this harbor is to excavate a channel 130 feet wide and 14 feet deep, through the rock that forms an obstruction in the entrance, and after this has been done, to build breakwaters from the eastern and western points, in order to define the entrance to the harbor.

There was estimated to have been 1,803 cubic yards of trap rock that had to be removed to effect this improvement, and at $81 per cubic yard the amount required to remove the rock was	$146,016 00
And there was appropriated	65,000 00

The work of removing this rock was let for $58 per cubic yard.

Upon a careful survey, made upon the ice during the winter, the number of cubic yards to be taken away, to give a channel 14 feet deep and 130 feet wide, has been ascertained to be 3,372 22-100, at a cost of $195,588 76.

The width of channel was reduced to 80 feet, and the contractor commenced his work with the knowledge that he was limited to the present appropriation for payment of all work done under this contract.

To make this cut 80 feet wide we calculated 2,040 cubic yards will have to be removed, at a cost of $118,320.

The contractor has removed 100 cubic yards of rock during the fiscal year.

There has been received from the Treasury Department, during the fiscal year, for this work $11,000 00
There has been expended 7,382 84
There is due appropriation on June 30, 1868 ..... 57,617 16

If the contractor receives his nitro-glycerine the whole of this amount will be expended this season.

The estimated cost of completing the excavation of the channel 80 feet wide, and building piers, is $184,025 00
This brings it slightly under the estimate of last year, which was 191,189 86

In that case the channel was 130 feet wide. If the channel be made 130 feet wide, we must increase the estimate $77,268 76, which would make the estimate for completion to be $261,293 76.

There can be profitably expended during the next fiscal year, $66,000.

(See Appendix A 3.)

4. *Marquette harbor, Michigan.*

The plan of improvement for this harbor is to build a breakwater about 2,000 feet long, commencing at the shore, and extending southward in front of the town. The breakwater to be composed of cribs, with grillage bottoms, filled with stone, each section having a width not less than the average height of structure above the bottom.

Estimate for completion $385,129 58
Amount appropriated 85,000 00

The work was commenced in August, 1867, and a section of five cribs, equal to 160 running feet of pier and about 100 running feet of stone embankment, connecting the crib work with the shore, were partially built in 1867.

The length of finished pier on the 30th of June, 1868, was 310 feet.

During the fiscal year there has been received from the Treasury Department, for this work $35,000 00
And expended during the same time 20,585 21
with liabilities still due.

There remains belonging to this appropriation, on the 30th of June, $64,414 79, which will be entirely expended this season, if the progress of the work is equal to our anticipations.

If appropriated in time, there can be profitably expended upon this harbor, during the next fiscal year, $100,000.

(See Appendix A 4.)

LAKE MICHIGAN.

5. *Green Bay harbor, Wisconsin.*

The plan for this harbor is to cut a new channel 200 feet wide and 12 feet deep, across Grass island.

The estimate for completion was $155,416 17
Amount appropriated 75,500 00

This work was commenced in the fall of 1866, but very little was done. Work was resumed in the spring of 1867 and vigorously prosecuted. From June 30, 1867, to June 30, 1868, 107,831 cubic yards of earth and sand were removed and dumped at distances of not less than three-fourths of a mile from the channel. At the present time there is a channel, with an average width of 100 feet and minimum depth of 9½ feet of water, in constant use by the bay steamers and vessels of light draught that navigate Green bay.

When the work was stopped, in 1867, careful measurements and soundings were made along and through the new cut. When the season of 1868 opened, and before the work was renewed, these soundings were again made, but few changes were found, and those unimportant.

A succession of heavy winds from the north and northeast, later in the season, affected the sides of the cut, and formed a small bar near the entrance on the northern side.

Hence it seems necessary, in order that this work should be finished properly, that the cut through the island should be revetted and the northern entrance protected by piers.

During the fiscal year there has been received from the Treasury Department	$47,002 28
Expended	45,900 81
Amount due appropriation	28,288 37

This last amount will be expended during the present working season.
Amount required next fiscal year, $82,500.
(See Appendix A 5.)

6. *Manitowoc harbor, Wisconsin.*

The plan is to build two parallel piers extending outward into the lake until the proper depth of water is obtained and to dredge the waterway between them.

The piers to be composed of cribs filled with stone.

The estimate for completion was	$141,747 82
Amount appropriated	97,000 00

There had been built on the 30th of June, 1868, 1,413 lineal feet of pier work; of this all had been finished excepting 13 cribs, making 416 lineal feet of pier that had been built to the surface of the water.

During the fiscal year there has been received from the Treasury Department for this work	$60,000 00
There was expended	50,168 53
There remained due the appropriation	19,984 06

This amount has since been expended.
There can be profitably expended during the next fiscal year, $27,500.
(See Appendix A 6.)

7. *Sheboygan harbor, Wisconsin.*

The recommendation of the last annual report is renewed by the officer in charge, and is approved. It is to extend the piers until the outer bar is crossed. This would require an additional 416 running feet of pier work and dredging. The estimated cost was $49,000.

The work done at this harbor in 1867, was an extension of the piers, amounting to 448 lineal feet of pier work.

In 1866, there was appropriated	$47,598 91
In 1867, there was appropriated	8,000 00
Total	55,598 91
Of which there had been expended on June 30	47,383 14
Leaving due the appropriation	8,215 77

This being available for dredging purposes, a contract was made with Lucius R. Muzzy, the lowest bidder, who was at the date of the report dredging the channel between the piers, whenever the weather was favorable.

The stone has settled considerably, and it may be necessary for the preservation of the piers to put in more ballast this fall.

There can be profitably expended during the next fiscal year $49,000.

(See Appendix A 7.)

8. *Milwaukee harbor, Wisconsin.*

The bar from the northward, encroaching upon the entrance to this harbor, mentioned in my last annual report, has enlarged, and to such an extent as to allow of no longer delay upon the work.

Contracts have been entered into for building the necessary pier work as far as the money on hand will allow.

There should be an extension of 400 lineal feet made to each pier, making 800 feet in all, composed of cribs not less than 25 feet wide, filled with stone.

The cost of this pier work would be not less than $100 per lineal foot.

The estimate for completion would be $80,000.

The amount that could be profitably expended during the next fiscal year, if appropriated in time, is $42,000.

During the year there has been received from the Treasury Department	$10,000 00
Expended	9,999 20

Leaving due to the appropriation, June 30, $38,284 31, which amount will be expended this season, if a fair rate of progress can be obtained.

(See Appendix A 8.)

9. *Racine harbor, Wisconsin.*

The plan proposed and adopted to extend both piers until they were in 15 feet of water has been partially carried out.

The estimate for completion was placed at	$84,172 48
On this estimate there was appropriated	45,000 00

During the year there has been built 544 running feet of pier; 128 feet of this pier required building up, and when the crib now building has been placed, the entire pier work for the north side will be finished.

The officer in charge urges the necessity of carrying out the south pier to the same distance, and thinks the amount estimated in the last annual report can be profitably expended during the next fiscal year in finishing up the work, viz., $40,000.

During the fiscal year there was received from the Treasury Department $50,000 00
And expended 47,927 97

There remains belonging to the appropriation $13,706 93, which will be expended this season.

(See Appendix A 9.)

10. *Kenosha harbor, Wisconsin.*

The plan for this harbor was given in Appendix A 9 of the last annual report. Estimated cost of completion, $55,000.

During the past season the extension to the south pier was entirely finished. That to the north pier was built, but not completely finished, in consequence of bad weather.

The time of completion has been extended, and the contractors expect to finish it this season.

Received during the year, $57,000 19; expended during the year, $59,086 42. There could be profitably expended during the next year $35,000. (See Appendix A 10.)

11. *Chicago harbor, Illinois.*

In the month of October, 1866, contracts were made for extending the north pier 600 feet, in accordance with plans previously adopted.

Timber and iron were obtained and arrangements made to have the stone ready to commence the work. Before the work was commenced in 1867 the Chicago Canal and Dock Company submitted a project for an entrance to their basin at the end of the pier. This project was approved by the Secretary of War, the company promising to close in the entrance to the basin by the end of the working season, and to assume any expense that might accrue to the contractor through departure from the original plan.

The officer in charge recommended in his annual report of last year the reduction of the length of new pier to 300 feet, as that would carry the extremity of the extension to the point originally proposed. But materials having been gathered together sufficient to build not less than 400 feet of pier, it has been thought best to use them in this extension.

Before the season closes, if nothing unforeseen occurs, it is believed that the Canal and Dock Company will have enclosed the basin, and that the 400 feet of pier will be built. This will place the extremity of the pier in 25 feet of water.

By not having enclosed the basin a drift of sand passed through the entrance, forming a bar near it. At the date of this report this was being removed by dredging.

The extension of the south pier would improve the harbor, and I therefore renew the recommendation made in the last annual report of $48,000 for this purpose.

During the year there has been drawn from the Treasury Department for this harbor $40,000, and expended $35,440 03, leaving due the appropriation on June 30, $40,178 13, which will be expended this season.

There can be profitably expended next season at this harbor.	$48,000 00
There has been allotted	35,000 00
Balance to be appropriated	13,000 00

(See Appendix A 11.)

12. *Michigan City, Indiana.*

The plan adopted for this harbor is to extend the piers, dredge out the river, and sheath pile the north bank of the river.

There was appropriated the sum of $75,000, and to complete the work an additional sum of $35,500 was asked for.

This amount can be profitably expended during the next fiscal year.

There has been excavated 38,684 cubic yards of earth, clay, and sand from the channel during the year. The failure of the contractor to deliver timber and do the framing has been the cause of serious delay.

It is expected that progress will be made before the working season closes.

An annual expenditure of $10,000 will be required for dredging between the channel piers, as well as around the bend, where the drift sand rapidly accumulates.

(See Appendix A 12.)

13. *New Buffalo, Michigan.*

The plan for improving this harbor is to connect Lake Pottawatomie and Lake Michigan by a cut. Under the present contract 70,563 cubic yards of material have been removed, and the sides of the cut partially revetted. The force of the current is insufficient to keep the cut open; the accumulation of sand at this locality is so great that no effectual improvement can be made but by at once following up the cutting from the inner lake with pier construction, which will involve a large outlay, say $325,000. The annual expenditure for dredging the channel of the drift sand is estimated at $10,000.

The subject of the improvement of this harbor was brought before a board of engineers, whose report was adverse thereto; but the appropriation act having directed the execution of the work, there was no other course to pursue than to commence the project with the means appropriated, and submit the results of the experiment in order that Congress may determine whether the improvement shall be continued. (The report of the board of engineers follows, Appendix D 9.)

(See Appendix A 13.)

14. *St. Joseph harbor, Michigan.*

The plan adopted is to repair the old piers and extend the south pier 200 feet.

This extension is a pier built of piles on a plan given by General Cram, with some slight modifications.

He hoped that this addition would compel the force of the current of the river to set directly out into the lake, and thus preserve the channel.

Although the pier has been carried out the required distance, the beneficial effect has not been proportional to the expectations.

The recommendation in the annual report of last year is renewed to extend the south pier the distance of 700 feet at a cost of $77,000. There has been allotted $7,500.

If appropriated in time the amount that could be profitably expended during the next fiscal year is $69,500.

(See Appendix A 14.)

15. *South Haven, Michigan.*

The plan adopted is to widen the mouth of the river to 120 feet, protect the banks with sheath piling, where excavation was made, building

two parallel piers, and dredge the water-way between the piers and across the bar opposite the entrance.

Estimate for completion	$129,000 00
Amount appropriated	43,000 00

During the fiscal year the work has been confined to extending the piers in the direction proposed. Eighteen cribs, making 576 running feet of pier, have been built, but not completely finished.

During the fiscal year there has been received for this work the sum of $32,000, and expended $29,672 39; and due the appropriation on June 30, 1868, $13,315 11; which amount will soon be exhausted. There can be profitably expended during the next fiscal year $43,000.

(See Appendix A 15.)

16. *Black Lake, Michigan.*

The plan adopted for this harbor is to extend the piers, close pile the cut, and dredge the channel to a depth of 12 feet. The estimate was $106,615 31; which amount has been appropriated. On the 30th of June, 1868, there had been dredged 81,945 cubic yards of earth and sand in making the required channel, and 352 feet of pier work built. This pier work will be finished this season.

During the fiscal year there has been received from the Treasury Department the sum of	$52,678 90
And expended	55,351 64
Leaving due the appropriation June 30, 1868	46,648 92

This amount seems sufficient to complete the work, and therefore no further appropriation is asked for.

(See Appendix A 16.)

17. *Grand Haven, Michigan.*

The plan adopted for this harbor is to defend the south bank of the river near its mouth with a close piling, and to extend the piers.

Estimate for completion of close piling and south pier	$105,111 21
Estimate for building north pier	200,000 00
Total for completion	305,111 21
Amount appropriated	105,000 00
Necessary for completion	200,111 21

During the fiscal year 1,943 lineal feet of close piling was finished, and the south pier extended 300 feet. This pier will be extended an additional 100 feet this season, and the work on the extension stopped.

There is danger of a breach being made in the old pier, and directions have been given to guard against it.

During the fiscal year there has been received from the Treasury Department for this work	$52,678 90
And expended	49,489 28
And due appropriation on June 30, 1868	30,295 61

Which amount will be expended this season. There can be profitably expended during the next fiscal year $75,000.

(See Appendix A 17.)

18. *Muskegon, Michigan.*

The plan adopted is to extend the piers and tear away the portion of the old piers above water and build up with a crib superstructure filled with stone.

The estimate for extending pier was	$58,450 00
The estimate for building up old piers	64,000 00
Total	122,450 00
There has been appropriated	59,000 00
Amount required for completion	63,450 00

During the fiscal year there has been built 384 running feet of pier.

During the year there has been received from the Treasury Department for this work $37,500, and expended $27,710 94, and due the appropriation on the 30th of June, 1868, $28,484 41.

The greater portion of this balance will be expended in extending the piers this season.

For building the upper part of a portion of the old piers, there will be required for the next fiscal year $10,000.

(See Appendix A 18.)

19. *White river, Michigan.*

The plan adopted is to make a cut 200 feet wide, close pile the sides of the new cut, and extend parallel piers until the depth of 12 feet is attained.

Estimate for completion	$171,000 00
Amount appropriated	57,000 00

During the fiscal year there have been removed 105,377 cubic yards of earth and sand, and about 1,000 running feet of close piling built.

During the fiscal year there has been received from the Treasury Department for this harbor $36,000, and expended $38,119 72; due appropriation June 30, 1868, $18,880 28.

This amount will be expended during the present season.

The dredging was stopped on June 6, as a further prosecution of the work of dredging would soon exhaust the appropriation, and it was necessary to retain a portion to finish the revetment of the cut.

There could be profitably expended during the next fiscal year the sum of $75,000.

(See Appendix A 19.)

20. *Pentwater, Michigan.*

The plan adopted for this harbor is to widen the present entrance, revet the sides of the cut with a close piling, extend outward into Lake Michigan two parallel piers, and to dredge a channel 12 feet deep.

Estimate for completion	$327,713 40
There was appropriated	55,000 00

On the 30th of June there had been built 320 running feet of pier to the surface of the water, and 15,944 cubic yards of earth removed from the channel. It was not intended to dredge the channel until the exten-

sion of the piers was finished, but so urgent was the appeal of the citizens to have an entrance into the harbor that their vessels could use and avoid the high rates charged by the owner of the pier on the north side, that the contractor for dredging was allowed to commence work.

It was of temporary benefit and will be of service in the future improvement.

During the fiscal year there was received from the Treasury Department for this harbor	$35,000 00
And expended	25,045 12
Due appropriation on June 30, 1868	29,946 88

There can be profitably expended during the next fiscal year $75,000. (See Appendix A 20.)

21. *Pere Marquette, Michigan.*

The plan adopted is similar to the one for Pentwater, and the estimate for completion was	$270,682 16
Amount appropriated	50,000 00

During the fiscal year there was built 608 running feet of pier, and 8,900 cubic yards of earth and sand removed from the channel. The pier has been built only to the surface of the water, but will be finished this season.

During the fiscal year there has been received from the Treasury Department for this work	$45,000 00
And expended	33,852 95
Due appropriation June 30, 1868	8,979 23

There can be profitably expended during the next fiscal year $75,000. (See Appendix A 21.)

22. *Manistee, Michigan.*

The plan adopted is to widen the entrance, extend parallel piers into the lake, and to dredge the channel to a depth of 12 feet.

The estimate for completion was	$180,949 00
Amount appropriated	60,000 00

During the fiscal year there has been built 448 lineal feet of pier work, and 18,326 cubic yards of earth and sand removed from the channel.

During the fiscal year there has been received from the Treasury Department for this harbor	$35,000 00
And expended	34,799 77
Due appropriation June 30, 1868, which will be expended this season	25,002 04

There can be profitably expended during the next fiscal year $60,000. (See Appendix A 22.)

23. *Aux Becs Scies, Michigan.*

The plan adopted is to make a new cut from Lake Aux Becs Scies (now known as Frankfort lake) into Lake Michigan, revet the sides of the cut, extend two parallel piers into the lake, and to dredge a channel 12 feet deep.

Estimate for completion	$146,400 00
Amount appropriated	98,541 00

During the fiscal year there has been 384 running feet of pier built, 525 running feet of close piling made, and 117,573 cubic yards of earth, clay, and sand removed.

During the fiscal year there has been received from the Treasury Department for this work	$55,000 00
And expended	66,227 02
Due appropriation on 30th June, 1868	31,481 82

This amount will be expended during the present season, together with the allotment of $10,000.

There can be profitably expended during the next fiscal year $38,000.

(See Appendix A 23.)

24. *Surveys in connection with the improvement of harbors on Lakes Superior and Michigan.*

(See Appendix A 24.)

HARBORS ON LAKE HURON AND ON THE WESTERN PART OF LAKE ERIE; IMPROVEMENT OF THE ST. MARY'S RIVER AND OF THE ST. CLAIR FLATS.

Officer in charge, Brevet Major General T. J. Cram, colonel corps of engineers, having under his orders Brevet Lieutenant Colonel F. Harwood, captain corps of engineers, until June, 1868, and Captain J. G. Lydecker, corps of engineers.

1. *Improvement of the St. Mary's river, Michigan.*

The work during the year has been confined to dredging the middle channel of Lake George; from July 1st to the close of the season of 1867, the material dredged amounted to 109,724 cubic yards. The work was resumed on May 12, 1868, and the amount dredged to the end of the fiscal year, June 30, was 28,691 cubic yards, making the amount of work done during the fiscal year 138,415 cubic yards, by two Osgood dredges.

The average performance of these two machines, in soft clay favorable for dredging, was $45\frac{78}{100}$ cubic yards per hour for each.

The officer in charge reports, as the results of a recent inspection, that there was at the date of his report at least 80,000 cubic yards yet to be dredged. This is 51,252 cubic yards in excess of the estimate made by him in 1866. This estimate was based upon surveys made in 1864, and the excess is due, in a great measure, to the filling up of the unfinished channel, (excavated in 1859,) between the date of the survey and the present time. The cost of removing this excess will exceed the amount available June 30, 1868, by $15,000.

Amount on hand July 1, 1867	$99,995 44
Amount expended to June 30, 1868	67,942 87
Leaving available	32,052 57
Estimated amount required to complete all the improvements contemplated in this river, exclusive of the improvement of the St. Mary's canal	$398,983
The annual amount required to keep the improvement in order when finished	10,000
The amount required for the next fiscal year for completing the dredging in Lake George, deepening the East Neebish channel and removing a shoal off the entrance to the canal is	40,000

(See Appendix B.)

LAKE HURON.

2. *Au Sable river, Michigan.*

An appropriation of $50,000 was made for this work by act of March 2, 1867. Owing to unavoidable delay contracts were not entered into until the end of the working season of 1867.

A considerable amount of materials were delivered in May and June, but no cribs sunk up to the close of the fiscal year.

Amount expended to June 30, 1868	$4,497 62
Leaving available July 1, 1868	45,502 38
Additional amount required to complete the work	20,000 00

The officer in charge is of opinion that this will always be an expensive harbor to keep open, (owing to the great quantity of sand coming down the river, and in the litoral current of the lake at this point,) for which an annual expenditure of $6,000 for dredging will be required.

(See Appendix B.)

3. *Improvement of mouth of Saginaw river, Michigan.*

A channel 195 feet in width and 12 feet deep is being cut, by dredging, through very hard material. From July 1, to the close of the working season of 1867, the material excavated amounted to 54,312 cubic yards. The dredging was resumed in April, 1868, and to the 30th of June the amount excavated with one dredge was 25,492 cubic yards, making an aggregate of 79,804 cubic yards since the commencement of the work. The average work done by the dredge during the year was $39\frac{6}{10}$ cubic yards per hour.

A large boulder rock and a sunken hulk have been encountered lying in the new channel. These will have to be removed during the present season, and if no further obstacles are met with the channel will be completed during the year. Since this report was prepared the engineer officer in charge has reported the completion (in October) of the channel. The officer in charge reports that no evidences have arisen, in the progress of the work, to indicate that the cut will fill up when made, but on the contrary, that the outflow of the river will keep it clear.

Amount available July 1, 1867	$95,077 35
Amount expended to June 30, 1868	66,928 06
Leaving available	28,149 29

An annual sum of $2,000 is estimated for by the engineer in charge to be expended in keeping this cut open, should it be found necessary.

(See Appendix B.)

LAKE ST. CLAIR.

4. *St. Clair flats.*

Contracts were entered into for a straight cut or canal 300 feet wide, 13 feet deep, and about a mile and a half long, through this shoal, on August 20, 1867. From that time until the end of the present fiscal year the work has been in active progress. The officer in charge reports that the character of the material excavated is highly favorable for the success of the plan of improvement adopted.

General Cram recommended that Seely's creosoting process be applied to the timber of the dykes above water, and requested that an appropriation of $27,300 be asked for for this purpose. This was submitted to the Secretary of War, approved by him, and transmitted to Congress. It is estimated by the officer in charge that by this outlay the saving for every period of seven years would amount to about the additional sum asked for.

Amount on hand July 1, 1867	$229,970 32
Amount expended to June 30, 1868	15,543 08

The original estimate of the probable amount required for this improvement was $428,754.

Additional amount required to complete the work	$200,000 00
To which add for creosoting remainder of timber to be used	25,000 00
Protection to foot of outer slope of bank	20,000 00
Total	245,000 00

Amount allotted from the appropriation of 1868	$86,000 00
Amount yet to be appropriated to complete the work	159,000 00

The officer in charge is of opinion that an average annual expenditure of $1,500 will probably be required for repairs and preservation, after the improvement is completed. Without the application of the creosoting process to the timber, he thinks this sum would have been incresed to $5,000.

(See Appendix B.)

LAKE ERIE.

5. *Monroe, Michigan.*

During the fiscal year much work has been done. The old parts of the piers have been completely repaired with new timber filled with stone and planked over.

A length of 300 feet interior to the shore end of the north pier has been filled with pile pier work, sheet piled on both sides and filled with brush and stone. This is to prevent the washing in of the sand which is again carried out by the freshet currents and deposited upon the outer bar. A length of 250 feet on the interior part of the south pier has been protected in the same manner during the fiscal year.

Amount on hand July 1, 1867	$24,255 21
Amount expended to June 30, 1868	13,665 00
Leaving to be expended hereafter as circumstances may require	10,590 21

The officer in charge estimates the probable annual expense of keeping this harbor in repair at $1,700.

(See Appendix B.)

6. *Harbor of Toledo, Maumee bay, Ohio.*

The work of deepening the old channel has been continued during the year.

From July 1 to December 1, 28,335 cubic yards, and from March 30 to June 30, of this year, 18,498 cubic yards had been removed; making

for the whole year 46,833 cubic yards; the average performance of the dredge was $38\frac{3}{10}$ cubic yards per hour.

As stated in my annual report of last year, this harbor, in view of its commercial importance, is one of those deemed necessary to be enlarged to an increased depth of 15 feet and width of 300 feet. The officer in charge estimates about $470,000 as the additional cost of such improvement. To carry out this plan an appropriation of $150,000 for the next fiscal year is required.

Amount on hand July 1, 1867	$35,435 38
Amount expended to June 30, 1868	22,420 37

(See Appendix B.)

7. *Improvement of Sandusky river, Ohio.*

The plan of improvement adopted was to make a channel from 160 to 200 feet wide and 12 feet deep, by dredging.

The work has progressed satisfactorily during the year. From July 1 to December 7, 1867, 20,716 cubic yards, and from May 10 to June 30, 1868, 26,931 cubic yards were removed, making for the whole fiscal year 41,697 cubic yards.

The dredge averaged $45\frac{6}{10}$ cubic yards per hour. This dredge is of the Otis patent, single engine, 15-horse power.

The balance on hand July 1, 1868, will be sufficient to bring the river to such a degree of improvement as will materially benefit the navigation, but will fall short of accomplishing the total amount of dredging that was in contemplation.

The officer in charge estimates that to complete the whole work as planned will require an additional appropriation of $35,000.

Amount on hand July 1, 1867	$19,992 40
Amount expended to June 30, 1868	11,659 79

(See Appendix B.)

8. *Sandusky City harbor, Ohio.*

The operations for the improvement of this harbor have been confined to dredging the channel through the outer bar, at the outlet of the bay into the lake, with a view of obtaining a channel width of 400 feet, and depth of 12 feet.

This bar is in a very much exposed place for dredging, moderate easterly winds, even, preventing the dredges from lying on the bar. The amount of work done from date of last annual report to close of the present fiscal year was the removal of 17,632 cubic yards of material. Average work of one dredge $29\frac{1}{2}$ cubic yards per hour in sand.

Amount on hand July 1, 1867	$38,577 90
Amount expended to June 30, 1868	14,224 14

As the balance is sufficient to continue the dredging of the outer bar to the extent required, no additional appropriation is asked for.

The officer in charge estimates the annual expense of keeping this channel open to be about $2,500.

(See Appendix B.)

9. *Huron harbor, Ohio.*

The work at this harbor is the rebuilding and repair of the dilapidated portions of the old piers, standing above water; sinking new cribs to rest on the foundations of those that have been swept away, and raising the

whole (with a new superstructure) to five feet above water; filling the piers with stone, and planking over all.

In October, 1867, the old piers had been repaired as far as necessary. During the winter and spring of the present year a small breach occurred in the old under-water work of one pier, and also one in another part of the old superstructure, and it will be necessary to protect the new lake extremity of the east pier, which seems to have been undermined.

These repairs will be done before the close of the present season.

The amount available will not only suffice to make the repairs mentioned, but will be sufficient for some years to come to make annual repairs.

Amount on hand July 1, 1867	$28,040 27
Amount expended to June 30, 1868	14,265 96

(See Appendix B.)

10. *Vermillion harbor, Ohio.*

The operations at this harbor have consisted in repairing the old piers wherever necessary, above and under water, and in raising them to five feet above water, filling with stone, and planking over all.

Until further damage or deterioration shall show a necessity for it, it is not intended to make further expenditures upon this work.

Amount on hand July 1, 1867	$3,328 59
Amount expended to June 30, 1868	3,328 59
In addition to this there was expended during the year, in the repairs and preservation of this work, from the general appropriation of 1864 for "repairs of lake harbors"	5,758 97
Making total expended in fiscal year	9,087 56

(See Appendix B.)

11. *Black River harbor, Ohio.*

Nothing has been done on this harbor during the last fiscal year.

The appropriation of $10,000 made in 1866 is still available for repairs, but there are indications of decay in the old parts of the west pier which will soon require attention.

The officer in charge estimates the average annual expense of keeping the work in repair to be about $1,500. He thinks that the present available sum applied to these repairs, as the necessity for them will arise, will keep the harbor in good condition for several years to come.

(See Appendix B.)

12. *Examination and surveys in connection with the improvement of harbors on Lake Erie.*

Special examinations and surveys were made with the view of perfecting the plans and estimates of cost and of locating the improvement for the harbors of Buffalo and Dunkirk, New York, and of Port Clinton, Ohio.

(See Appendices B and B 1.)

HARBORS ON LAKE ERIE, FROM CLEVELAND, OHIO, TO ERIE, PENNSYLVANIA, INCLUSIVE.

These harbors were under the direction of Brevet Major General T. J. Cram, colonel of engineers, up to May 28, 1868. Subsequent to that date they have been under the direction of Major Walter McFarland, corps of engineers.

1. *Cleveland harbor, Ohio.*

The plan of improvement for this harbor is one recommended by General Cram, and is denominated a pile pier, which he regarded as peculiarly adapted to this locality. It is an experiment which was justified by economy of cost, but it remains to be tested whether it has any advantage over the crib-pier, even at this locality.

The west pier has been extended 450 feet upon this plan.

Amount available July 1, 1867		$51,590 45
Expended under contract by General Cram	$17,554 32	
Expended under contract by Major McFarland	3,177 14	
		20,731 46
Available June 30, 1868		30,858 99

Amount required (in addition to balance) to complete present plan, $4,000.

This is one of the harbors selected for an increased depth, to admit vessels of 14 feet draught, for which the estimate is $39,000.

The amount that may be profitably expended in the season following the appropriation is $25,000.

(See Appendix C.)

2. *Grand River harbor, Ohio.*

The work during the past year consisted of repairs of the old piers, in the construction of nine cribs for east pier extension, and in the placing of four of them.

The action of the spring freshets caused the undermining of the entire length of the four cribs, and their settlement to the clay substratum at the outer end, from six to eight feet below the sand bottom on which they had been placed.

Amount available July 1, 1867		$53,310 22
Expended under contract by General Cram	$8,128 10	
Expended under contract by Major McFarland	93 12	
		8,221 22
Balance June 30, 1868		45,089 00
Probable cost of east pier crib extension		21,631 00
Leaving		23,458 00

available for the extension of the west pier parallel to the east pier, or other modification of the plan as may be necessary after the completion of the partial plan now in progress.

(See Appendix C 1.)

3. *Ashtabula harbor, Ohio.*

The work was limited to the repair of the old piers, and in preparation for extension of the east pier, while under the charge of General Cram. Since the transfer to Major McFarland, eight cribs of the extension, of a total length of 240 feet, have been built, floated to their position and

sunk, in accordance with the plan which contemplates the equal extension of both piers.

Amount available July 1, 1867		$72,764 29
Expended under contract by General Cram	$17,461 27	
Expended under contract by Major McFarland	6,992 86	
		24,454 13
Balance June 30, 1868		48,310 16

The repairs of the old work having exceeded the estimate of General Cram, there will be required a further appropriation for completion of $2,100.

(See Appendix C 2.)

4. *Conneaut harbor, Ohio.*

The repairs of the old piers have been made. In the spring a freshet caused a breach behind the east pier, which will cost, as estimated	$9,000 00
Cost of extension of west pier	22,771 00
Cost of dredging channel	6,181 00
Total cost	37,952 00
Expended under contract by General Cram	16,196 45
Balance	21,755 55

or, to complete the work of improvement as proposed, there is required a further appropriation of $22,000.

(See Appendix C 3.)

5. *Erie harbor, Pennsylvania.*

The operations in progress for the improvement of this valuable harbor were well advanced, the pier having been extended 500 feet, and the channel ever the outer bar dredged to a width of 200 feet, and 14 feet in depth, when a severe gale damaged the pier so seriously as to render it expedient to lay the subject before a board of engineers, whose report is appended hereto.

Preparations were made by the officer in charge, in accordance with the views of the board of engineers, to remedy the disaster, and contracts were entered into by him.

There was expended by General Cram	$43,873 49
There was expended by Major McFarland	3,610 09
Total expended	47,483 58
Leaving a balance July 1, 1868	$12,350 91
Allotment of the appropriation for repairs, &c., 1868	40,000 00
Total available for improvements	52,350 91

The estimated cost of the repairs of the damaged pier	$16,000 00
Estimated cost of dredging outer bar.....	5,000 00
Estimated cost of dredging inner bar.....	35,000 00
Total.....	56,000 00
Leaving a balance to be appropriated of.....	~~$3,640 00~~
The old works will need repairs, the estimate for which is..	34,000 00
Making a total amount for the next fiscal year	37,650 00

This harbor is one of those selected for increased depth of channel to admit vessels drawing 14 feet, the estimate for which is $35,000, a sum that may be profitably expended during the season subsequent to the date of the appropriation.

(See Appendices C 4 to C 11, inclusive.)

HARBORS ON LAKE ERIE, EAST OF ERIE, PENNSYLVANIA.

These harbors were under the charge of General Cram until June 3, 1868, at which date he was relieved by Brevet Lieutenant Colonel Franklin Harwood, captain of engineers.

1. *Dunkirk harbor, New York.*

The repairs of the pier connecting the beacon-light foundation with the main land, a length of 1,380 feet, have been well advanced, and already arrest the washing of sand into the harbor, as well as offering partial protection to the harbor against the swell of the sea.

The breakwater has not yet been commenced, but bids have been invited, and the work will be shortly under contract, the balance of the appropriation being adequate for the construction of about 1,000 feet, after reserving an amount to meet contingent expenses and repairs.

The officer in charge recommends the removal of the remains of the outer breakwater commenced under an appropriation made in 1852. It is now an obstruction to navigation, and authority has been given for its removal to a depth of 14 feet below the surface of the water at the lowest stage.

Amount on hand July 1, 1867.....		$100,000 00
Expended by General Cram.....	$8,329 65	
Expended by Colonel Harwood.....	3 80	
		8,333 45
Balance, July 1, 1868.....		91,666 55

and will be expended, under contract, for completing beacon-pier, for building about 1,000 feet of breakwater, and removal of the old breakwater.

For continuing the plan of improvement an appropriation is required of $50,000, which can be profitably expended next season.

(See Appendices D to D 5, inclusive.)

2. *Buffalo sea wall, New York.*

This work remains as reported in the last annual report. It has been recommended to await its further construction until the works for the

improvement of Buffalo harbor, now in progress, have been further advanced.

The balance of appropriation for the sea wall is $23,751 39.

(See Appendix D.)

3. *Buffalo harbor, New York.*

The plans for the improvement of this harbor were brought before a board of engineers for consideration. Their recommendations were approved, and the work is under contract for the building of so much as the appropriation will admit, namely, the repairs of pier-head and tow-path, the extension of the pier, and the construction of about 900 feet of breakwater.

Amount on hand July 1, 1867		$200,000 00
Expended by General Cram	$3,084 38	
Expended by Colonel Harwood	3,790 80	
		6,875 18
On hand, July 1, 1868, and now under contract		193,124 82

For the continuation of the work there is required an appropriation of $275,000, which may be profitably expended during the next fiscal year.

(See Appendices D and D 6 to D 15, inclusive.)

HARBORS ON LAKE ONTARIO.

Brevet Colonel C. E. Blunt, lieutenant colonel of engineers, has charge of these improvements, and is assisted by Captain W. A. Jones, corps of engineers.

1. *Olcott harbor, (Eighteen-mile creek,) New York.*

Contracts for this harbor have been entered into and partially executed. The channel of the creek has been modified by the removal of a portion of the bar, and an old pier has been rebuilt in connection with the proposed new work.

The plans proposed and approved, and which will be partially carried out with the amount appropriated March 2, 1867, contemplate the construction of two parallel piers, 200 feet apart and 1,000 feet each in length, and dredging to give 10 feet of water.

The late delivery of the timber has prevented the accomplishment of as much work as was hoped could be finished by July 1. If the contractor for labor fulfils his agreement, considerable work on the new pier can be executed before the close of the season.

Amount appropriated March 2, 1867	$60,000 00
Amount expended during the year	9,328 33
Amount estimated for completing the work	118,000 00
Amount required for next fiscal year, which may be profitably expended during the next season	58,000 00

(See Appendix E.)

2. *Oak-orchard harbor, New York.*

The timber in part, and all of the iron, required for the improvement have been delivered under the contracts concluded during the previous year, but no work has been done. Colonel Blunt reports that the contractor will probably abandon his contract.

This will involve delay in the completion of the improvement; but little detriment to the public interest will ensue, as the business and commerce of the harbor are represented to be small. The value of the harbor consists in its being one of refuge, lying east of Niagara river 45 miles and west of Genesee river 30 miles. Both of these harbors offer great facilities as places of refuge.

Amount on hand July 1, 1867	$87,000 00
Amount expended	12,206 89
Amount available July 1, 1868	74,793 11

(See Appendix E.)

3. *Mouth of the Genesee river, New York.*

Since the last annual report, the rebuilding of the west pier has been completed, and that of east pier is well advanced. By the end of the season this east pier will be completed as far as the balance available will permit.

An allotment of the appropriation for repairs, &c., made in 1864, has since been made, which will enable the officer in charge to complete the pier at its lake extremity.

The end of the east pier uniting with the main land requires repair and extension to guard against a threatened breach.

To cover these repairs and extension, Colonel Blunt estimates to be required $10,000, which can be profitably expended next season.

Amount on hand July 1, 1867	$75,607 80
Amount expended	55,611 86
Amount available July 1, 1868	19,995 94

All under contract. Required to be appropriated, $10,000.
(See Appendix E.)

4. *Big Sodus harbor, New York.*

The work under the old contracts and that under the new contracts, reported herewith, has progressed satisfactorily on the whole. Up to June 30, 840 feet of the west pier have been completed, and 240 more rebuilt to the water level.

The wreck of a schooner in mid-channel, obstructing the passage, has been removed by special contract. A narrow channel has been obtained by dredging, so that vessels drawing 10 feet have gone in.

It is thought the balance, $58,645 46, still available, will be sufficient to do the remaining necessary work in rebuilding piers and dredging channel, and no further appropriation is asked at present.

(See Appendix E.)

5. *Little Sodus harbor, New York.*

The dredging of the channel and extension of the west pier, under contracts reported in 1866, and new contracts reported herewith, have been steadily continued.

Five hundred feet of new pier have been completed and 300 more brought up to the water level. This unfinished part, it is hoped, will be completed this season.

The dredging of the channel has been, and is still, going on. It is now 80 feet wide.

The opening between the pier and the west shore has been closed up by a cheap crib-work. A short east pier is deemed advisable to define the channel, and the opening on the east side of the harbor should also be closed.

For these objects, deemed necessary to complete the improvement, the request of last year for a further appropriation of $25,000 is renewed.

Amount on hand July 1, 1867	$83,533 88
Amount expended	55,673 37
Amount available July 1, 1868	27,860 51

Amount required to complete plan, $25,000.

(See Appendix E.)

6. *Oswego harbor, New York.*

The dredging of the harbor and repairs of United States pier have been continued during the year under contracts heretofore and now reported.

The dredging so far executed has rendered available for vessels a great part of the pier and portions of the harbor which had been useless for years. It is believed that all the dredging necessary for the present can be completed before the close of 1868.

The old pier will continue to need an annual expenditure for its repair; but unless a very large breech should be made, no additional appropriation for this repair will be needed for two or three years.

For the extension of the pier northerly into the lake, a much needed improvement, $50,000 is required and is asked for next fiscal year.

Amount on hand July 1, 1867	$69,373 40
Amount expended	19,550 48
Amount available July 1, 1868	49,823 92

Instructions have been given for the commencement of the extension of the pier with a portion of the balance on hand, and with an allotment of $20,000 from the appropriation for repairs, &c., made during the last session of Congress.

For the contingent repairs of the old pier, and for the further extension of the new pier, an appropriation of $50,000 is required and can be profitably expended during the next fiscal year.

(See Appendices E and E 1.)

7. *Ogdensburgh harbor, New York.*

The dredging, which it is stated in the last report was expected to be done that season, was executed, the contractor stopping work November 30, 1867; but instead of resuming work in the spring of 1868, he abandoned his contract on the ground that the material to be removed was harder than he had been led to believe. (His bid was unreasonably low

in price.) A second board of engineers having examined the harbor, a revised plan of improvement has been submitted and proposals have been invited for the dredging. Contracts have not yet been made, but it is hoped that they will be in time to resume operations during the latter part of the season of 1868.

Balance available July 1, 1868, $37,118 58.

(See Appendices E, and E 2 to E 9, inclusive.)

SURVEY AT PORT ONTARIO, MOUTH OF SALMON RIVER, NEW YORK.

A special report of this survey was made in compliance with a resolution of Congress of 17th January, 1868.

The estimated cost of construction is	$209,000
For construction of piers	90,000
For dredging channel and so-called harbor	119,000

It does not appear that the wants of commerce and navigation require the construction of a harbor at the cost estimated.

(See Appendix E 12.)

SURVEY FOR A SHIP CANAL BETWEEN LAKES ERIE AND ONTARIO.

This survey was made under the direction of Brevet Colonel Blunt, corps of engineers, in compliance with a joint resolution of Congress of March 22, 1867.

The importance of an uninterrupted water communication between these two lakes for the largest class of vessels was, as early as 1808, considered worthy of the efficient aid of the general government.

In 1826 a survey was made under an association of private individuals, and another in 1835, by Captain W. G. Williams, corps of topographical engineers, in obedience to a resolution of the House of Representatives.

In the able report of Captain Williams, five different lines, two of which nearly coincide with the Four-mile creek and Twelve-mile creek routes of the present survey, were carefully considered and estimated for at the prices of that day.

Preference was given to a route near to and debouching into the Niagara river.

The five separate routes presented by Colonel Blunt as feasible for the canal in question do not differ as materially in cost as in length.

Upon the shorter, or Lewiston routes, the proposed system of double locks, indispensable from the great amount of lockage required in a short space, makes the cost relatively greater. And of the longer routes, the Four-mile creek and the Twelve-mile creek routes have their cost relatively increased by more rock excavation and more double locks, when compared with the Eighteen-mile creek route. The Eighteen-mile creek route best fulfils the conditions of security by being further removed from the frontier, and as its terminus is 15 miles further east on Lake Ontario than the average of the others, viewed as a route for commerce it is that much shorter. Its greater security against secret enterprise, during and just preceding a war, renders it preferable for commercial as well as for military and naval purposes.

Were the canal extended from Tonawanda to Buffalo harbor, its extension would not be better protected against an enemy than the river would be. Its extension is therefore deemed unnecessary.

The average cost of the projected canal would be about $12,000,000; and after a careful examination of the estimated cost of the several pro-

jects as given in detail in Colonel Blunt's report, it appears to be probable that they could not be executed for less sums than those estimated.
(See Appendix E 10.)

SURVEY OF WILSON HARBOR, (TWELVE-MILE CREEK,) NEW YORK.

A special report of this survey, with an estimate for the cost of the improvement, was made on the 11th of March last, in compliance with the resolution of the House of Representatives, dated February 26, 1868.

This harbor is situated 12 miles east of the Niagara river and six miles west of the harbor of Olcott. At the latter there has been appropriated $60,000, which is now being expended.

Private parties have built piers at Wilson which afford a depth of six or seven feet into the harbor, but to make a suitable harbor an expenditure of $155,000 would probably be required. Should it become the terminus of a canal around the falls of Niagara, a harbor would be indispensable at this locality.

A report made in 1854, with plan and estimates for a harbor at Twelve-mile creek, will be found printed in Ex. Doc. 62, 33d Congress, 1st session.
(See Appendix E 11.)

HARBORS ON LAKE CHAMPLAIN.

The works of improvement on this lake were in charge of Brevet Colonel C. E. Blunt, lieutenant colonel corps of engineers, until January, 1868, when they were placed under the direction of Brevet Lieutenant Colonel J. W. Barlow, captain corps of engineers.

1. *Plattsburg harbor, New York.*

The repairs of the breakwater were completed under the direction of Colonel Blunt.

The remaining improvement, which consists in dredging out the shoal lying between the breakwater and the wharves to the depth of nine feet, has been conducted by Colonel Barlow.

The extension of the breakwater northwardly some 300 feet and the revetment of the bank of the government reservation have been recommended to meet the increasing commercial interests of the harbor.

The balance available for dredging is $6,000. A further appropriation to complete the dredging is required of $20,000, which may be profitably expended next season.
(See Appendix F.)

2. *Burlington harbor, Vermont.*

The charge of this harbor was transferred by Colonel Blunt to Colonel Barlow December 12, 1867. The contracts for labor and material after serious delays have been finally entered into, and considerable progress has been made.

The plan recommended by the board of engineers, and adopted for the improvement is to extend the present breakwater northwardly 1,200 feet, making the entire length 2,660 feet.

The extension is being made by cribs of timber, rectangular in cross sections, having a base of 30 feet, and a height of 40 feet, ballasted with stone.

The estimated cost of extension	$333,442 00
The amount available July 1, 1867	107,672 20
The amount expended	17,254 66
The amount available July, 1868	90,417 54

And all under contract.

The further appropriation of $75,000 is required for the next fiscal year.

(See Appendix F 1.)

SURVEYS AND IMPROVEMENTS OF THE UPPER MISSISSIPPI, MINNESOTA, AND WISCONSIN RIVERS, AND INVESTIGATIONS RELATIVE TO BRIDGING THE MISSISSIPPI AND OHIO RIVERS.

Officer in charge, Brevet Major General G. K. Warren, major corps of engineers, having under his orders Brevet Major C. R. Suter, captain corps of engineers, and H. C. Long, United States civil engineer.

Surveys and maps of the Mississippi river.

Owing to continued high water in 1867 but little was done in surveys before 1st October. From 12th June to 28th November (at which last date the river was closed by ice) a party was engaged measuring the river.

Of the river surveyed, 19½ miles were resurveys of the work of 1866, to determine changes in the bed and banks, and rate of progress.

These surveys have all been platted, and the plats reduced to a scale of two inches to the mile, and transferred to the map on that scale, extending from the Falls of St. Anthony to the mouth of the Ohio, combining in this, with the Land Office surveys as a basis, all the information obtained.

An examination was also made from the mouth of the Des Moines to the mouth of the Ohio, to determine the exact position of the bluffs, and connect the Land Office surveys of the two sides of the river.

Survey and maps of the Wisconsin river.

This survey, under Brevet Major Suter, corps of engineers, was commenced August 26, and finished November 6.

Surveys and maps of the Minnesota river.

An examination was made of this river in 1867, from Lac Traverse to its mouth to determine the character of the terraces and of the main bluffs.

Surveying outfit consists of two large flat-boats, fitted up for quarters, and about 25 small row-boats and skiffs. It is recommended by the officer in charge that a small propeller be added for the Mississippi above the rapids, at a cost of about $3,000.

Additional surveys.

It is believed no further surveys will be required on the Minnesota and Wisconsin rivers, except in some limited spaces. There is a necessity for completing the survey of the Mississippi, so as to present a continuous map from the Falls of St. Anthony to Rock island rapids. This

would require $30,000 for the survey and finishing the maps. The examination and survey of the river above the falls will require $10,000.

Some additional measurements are necessary to complete the collection of material relating to bridging the Mississippi river, and completing maps and diagrams, which will require $6,000. It is deemed important that these examinations and surveys should be vigorously prosecuted.

Improvement of the river.

The obstructions along the main trunk streams are generally sand-bars, and as this sand extends down to great depths the only economical improvements are dredging out the sand-bars, constructing wing dams to force the water to cut them out, and side canals with locks. The Minnesota river, particularly in its upper course, is more favorable for dams and locks.

Bridging the Mississippi river.

The great trough of the ancient Mississippi widens as we descend from one mile at St. Paul to ten miles at St. Louis. As the broad low valley, however, renders the construction of high bridges very expensive, drawbridges have so far been adopted.

The crossing of the Mississippi by a railroad bridge which shall not obstruct navigation is a serious undertaking; no bridge has yet been built that can claim to be of that character. This part of the detailed report is being prepared with great care to meet the wants of future legislation. Suggestions are made by General Warren relative to the foundations of bridges based upon his own deductions, and information received from several bridge engineers on the river.

(See Appendix G.)

Bridging the Ohio river.

An examination was made of the Steubenville bridge in June last, and a report made upon it to this office, with an estimate for building a high bridge with 500 feet span. This report shows that a defective location reduces the 300 feet span which exists, as provided by law, to 250 feet width only for navigation. A draught of provisions required to secure to navigation the full benefit of the passage way, as fixed by law, &c., in future constructions, accompanies this report.

The Ohio river is more favorable in all respects for continuous high bridges than the Mississippi. The pools in the river afford the best locations for bridges to accommodate navigation.

(See Appendices G and G 3.)

Improvements on the upper Mississippi river.

The sum of $96,000 was appropriated for the construction of two dredge and snag boats on the upper Mississippi, and for working them one year. The officer in charge reported in April, 1868, that there remained, with the two boats purchased, $20,181 39 unexpended, which would be required before the end of the year for repairs, &c. He estimates that $36,000 would be required to continue them in service during the coming year. These boats were found to work satisfactorily, and it is considered important that they should be kept in service. The officer in charge believes that an increased depth of one foot is as great an

alleviation as can be relied on by scraping without a disproportionate expense, and in certain localities that it would probably be necessary to resort to wing dams and jettees; these dams to be applied according to the peculiar requirements of the river. He recommends an appropriation of $25,000 to test this kind of improvement at two localities, and that a provision should be inserted in the bill to allow the engineer in charge of the work certain discretion in regard to closing channels, &c.

The operations of the boats during the months of July and August were very satisfactory.

The period of low water came unusually early this season, and at first stopped the large boats from running. The dredge boats were at the time undergoing repairs and alterations to fit them for snagging. The Caffrey was hastily fitted up for scraping, and put to work upon the bars; and although she had to perform double duty, she restored navigation for the largest boats and has maintained it ever since. The officer in charge states that the steamboat owners became so satisfied of her usefulness that they obtained the use of an extra scraper to put on one of their own boats and work at their own expense between Keokuk and St. Louis.

These boats may be regarded as a success in so far that they have enabled the largest steamboats to reach St. Paul two consecutive years, when they would otherwise have been compelled to lay up, and justifies the recommendation for an appropriation to continue their operations the ensuing year.

The steamboats Montana and C. I. Caffrey were purchased in 1867 for $30,000 and $8,500 respectively.

For continuing the improvement of the upper Mississippi river during the next fiscal year there is required $65,000.

(See Appendices G and G 1.)

Improving the Minnesota river.

An advertisement was inserted in ten leading western and northwestern newspapers for proposals for removing snags and boulders from the above river, in answer to which six proposals were received. The contract was given out and an assistant was appointed to superintend the work. In prosecuting operations during the season of 1867, the work was frequently impeded by leaning trees on the banks, which were liable to become still greater obstacles by being washed into the river. There were also in the ravines and along the banks of the tributaries a large number of trees, which the next high water would bring into the Minnesota. As the removal of these obstacles did not come within the contract, a party of axemen was employed during the winter months cutting these out. Of $37,500 appropriated for this work $28,289 15 has been expended, and the balance, $9,210 85, will all be expended, with favorable weather, this season; and, it is believed, will nearly clear the river as far up as Mankato. An additional appropriation of $20,000 is asked to carry on the work above that place.

An appropriation of $30,000 is also solicited to make a practicable passage at the Little Falls.

(See Appendix G.)

Wisconsin river.

This improvement is intended to form part of a line of communication by steamers from the Mississippi river by way of the Wisconsin river, Upper Fox, Lake Winnebago and Lower Fox river to Green Bay, and thence with the lakes.

General Warren, in his report of April 8, 1868, expressed himself in favor of an improvement of the river, by dams, jettees, revetments, &c., of brush and stone in connection with dredging, in preference to a canal along the banks or to locks and dams in the river.

The question as to kind of improvement will mainly turn upon the making of a 3 feet, 4 feet, or 5 feet navigation, at a cost, respectively, of $500,000, $3,250,000 and $4,300,000 nearly, as appears in his annual report of the present year, herewith appended.

As much experience is yet to be acquired, General Warren recommended in his April report an appropriation of $50,000, which, with the balance on hand, would enable him to test this method of improvement more fully than has yet been done.

In the absence of a decision by Congress upon these projects, an estimate for the next fiscal year is recommended, (to be applied to the experimental improvement of the river by wing dams and by the use of the Long scraper,) of $50,000.

Public importance of these river improvements.

In presenting the general considerations on this subject, the moving of the wheat crop has been mainly kept in view by the officer in charge, but in no case does this show more than half of the benefit to an improved navigation that would result from transportation of all products combined.

Statistics and estimates are given of the product of the wheat-growing country and the relative cost of railway and water transportation, showing that many millions of dollars would be saved to producers and consumers by water transportation, were it as good as it is capable of being made, under the plans of improvement suggested. It is probable that the development of the resources of the new States will be so rapid in all the wheat-growing region that all the proposed means of transportation will be wanted as fast as they can be made available.

Harbor at Alton, Illinois.

The report upon the survey of this harbor, made under the direction of Brevet Major General G. K. Warren, by H. C. Long, United States civil engineer, which was called for by resolution of the House of Representatives of April 13, 1868, will be found in Appendix G 2.

IMPROVEMENT OF THE DES MOINES AND ROCK ISLAND RAPIDS OF THE MISSISSIPPI RIVER, AND THE SURVEY OF THE ILLINOIS RIVER FROM LAKE MICHIGAN TO ITS MOUTH.

Officer in charge Brevet Major General James H. Wilson, United States army, lieutenant colonel 35th infantry, having under his orders Brevet Major Charles J. Allen, United States army, captain corps of engineers; L. Cooper Overman, captain corps of engineers; F. Hoffman, second lieutenant 35th infantry; and Daniel C. Jenné, United States civil engineer.

1. *Improvement of the Des Moines rapids of the Mississippi river.*

Proposals were invited September 4, 1867, for excavating the prism, and for constructing the embankment wall of the canal, or for as much thereof as the amount then appropriated, namely, $700,000, would pay

for. Contract for the work was awarded to W. Hennegan & Son, the lowest bidders, and concluded on the 25th of the same month. Amount expended under this contract up to and including June 30, 1868, $103,020.

Proposals for materials and labor for the construction of the locks were invited February 27, 1868, and the awards made to the lowest bidders for the different classes of materials and labor May 2, with instructions to contract with the same whenever funds should be made available, and upon their complying with the requirements of the law. No contracts under this letting had been entered into at the close of the fiscal year, but under the allotment to this work from the recent appropriations a contract for the lower lock was entered into.

Amount appropriated June 23, 1866	$200,000 00
Amount appropriated March 2, 1867	500,000 00
Total	700,000 00
Amount required for completion of the work	$1,480,000 00
Amount required for next fiscal year	850,000 00
Allotment from general appropriation	300,000 00
Balance to be appropriated for next fiscal year	550,000 00

(See Appendices H and H 1 to H 6, inclusive.)

2. *Improvement of the Rock Island rapids of the Mississippi river.*

Additional surveys were made, and about 100,000 soundings taken, from which very accurate charts of the river bed were projected. This was deemed necessary in order to obtain such minute information as to secure accuracy in laying out the work and determining the extent and character of the improvement, the surveys made during the fall of 1866 being necessarily imperfect and wanting in detail, on account of the limited time and means at the disposition of the officer in charge of the work.

Operations under the contract of C. G. Case & Co. were not commenced until September 18, owing to the high water and the difficulty of procuring such machinery as was necessary; 3,898 cubic yards of rock were removed during the fall of 1867 and spring of 1868 from Duck Creek chain.

Proposals for continuing this work were invited May 18, and the contract awarded to C. G. Case & Co., (the old contractors,) with whom the officer in charge was directed to enter into contract as soon as an appropriation was made by Congress.

No contracts were made prior to June 23, 1868. Under the allotment to this work from the recent appropriations, a contract was entered into and the work is progressing.

Amount appropriated June 23, 1866	$100,000 00
Amount appropriated March 2, 1867	200,000 00
Amount of allotment August, 1868	156,000 00
Total	456,000 00
Amount required for completion of the work	$394,000 00
Amount required for next fiscal year	394,000 00

(See Appendices H and H 7 to H 12, inclusive.)

3. *Survey of the Illinois river.*

The act of March 2, 1867, authorized the continuation of the survey of the Illinois river, with a view to a deep-water connection with Lake Michigan.

The survey was commenced early in June under the direction of a board consisting of Brevet Major General James H. Wilson, United States army, lieutenant colonel 35th infantry, and Mr. William Gooding, United States civil engineer.

A detailed and exhaustive survey of the country between Lake Michigan and La Salle, and a low-water survey of the river from La Salle to its mouth, was made, resulting in a recommendation to widen and deepen the Illinois and Michigan canal from Bridgeport to the head of Lake Joliet, with the exception of a section of about 11¼ miles between Summit and "The Sag," where it will be cheaper to excavate a new canal.

From Lake Joliet the line will follow the bed of the river, the construction of a piece of independent canal, to pass the Grand Rapids of the Illinois river, striking the river again at or below Ottowa, being necessary; thence to the mouth of the river, the navigation is to be secured by a system of locks and dams. The width of the canal to be not less than 160 feet; the depth six feet below the lowest known level of the water in Lake Michigan. The locks to be 350 feet long between the gates, and 75 feet wide in the chamber, and to give a minimum draught of seven feet; the slack water in the river to be at least seven feet in the lowest water.

The estimated cost of the improvement from Lake Michigan to the mouth of the Illinois river, is $18,217,242 56.

The amount of $85,000 was alloted to the Illinois river from the general appropriation of $1,500,000, to be applied to the improvement of the river from La Salle to its mouth. This amount, however, was found to be inadequate for the commencement of the plan of improvement recommended by the board of engineers, where the least cost of a lock and dam at any of the designated points below La Salle is estimated in round numbers at $300,000. The lock and dam should be built simultaneously, and no general system of improvement of this river by locks and dams should be begun until money enough has been provided to complete and open for use at least one lock and dam. In consideration of the difficulties and magnitude of the improvement it is not deemed practicable to begin with a less sum than $300,000, which can be profitably expended next year.

Cost of improvement from La Salle to the mouth of Illinois river	$1,953,600 00
Required for next fiscal year	300,000 00

(See Appendices H, H 13, and H 14.)

Railroad levee on west side of Mississippi river.

The Committee on Freedman's Affairs in the House of Representatives having, through its chairman, requested information concerning a project for constructing a railroad along the bank of the Mississippi river, from the mouth of the St. Francis river, to a point west of Girardeau, the bed of the road to be used as a levee, &c., the subject was referred to Brevet Brigadier General H. L. Abbot, major corps of engineers, for a report, he being possessed of the requisite information, from his con-

nection with the surveys and investigations made in 1857–'61, for determining the most practicable plan for securing the alluvial banks of the Mississippi from overflow, and with later examinations of the levees of the Mississippi in 1865–'66.

I concur with General Abbot in the views he has taken of this project. See his report.

(Appendix H A.)

IMPROVEMENT OF THE MOUTH OF THE MISSISSIPPI; SURVEY OF GALVESTON HARBOR, TEXAS, AND SURVEY OF PASS AND BAYOU MANCHAC AND AMITE RIVER, LOUISIANA.

Officer in charge, Brevet Brigadier General M. D. McAlester, major corps of engineers, having under his orders Brevet Major W. J. Twining, captain corps of engineers, and First Lieutenants D. W. Payne, W. S. Stanton, and M. R. Brown, corps of engineers.

1. *Survey of Pass and Bayou Manchac and Amite river, Louisiana,*

with a view of determining the feasibility of establishing first class steamboat navigation on that line, between the Mississippi river and Lake Pontchartrain.

The charts and plans appertaining to this survey were completed in the month of December, 1867, and, with the report dated January 9, 1868, were received during the latter month. They were submitted to Congress.

(See Appendices I and I 3.)

2. *Survey of Galveston harbor, Texas,*

with a view of forming a plan for its preservation and improvement.

This survey has been completed, and a full report thereof, dated June 9, 1868, received, with accompanying documents, charts and plans. It was duly transmitted to Congress.

(See Appendices I, I 4, and I 5.)

3. *Improvement of the mouth of the Mississippi river.*

On the 13th of September, 1867, proposals for constructing and delivering the authorized dredge-boat, designed for deepening the channels, were opened. Only two proposals were presented, which were unacceptable, since they exceeded, not only the careful estimate of the cost of building and delivering the vessel, but also the amount of funds available. Both were therefore rejected, and notice issued anew. Five proposals were received, and the contract was awarded to the "Atlantic Works," of East Boston, Massachusetts. The contract and bond were executed on the 15th of October.

On the 17th of October First Lieutenant D. W. Payne, corps of engineers, was assigned as inspector of the dredge-boat at Boston, in order to secure a faithful performance of the contract.

Delays occurred in the construction of the steamer, and in her delivery, arising chiefly from the novelty of construction, and she did not reach New Orleans until July of this year.

This steamer is now employed upon Pass à l'Outre, and exceeds the anticipations that were formed of her effectiveness, having in 12 hours work increased the depth over the bar from 11 to 14 feet, on a width sufficient for the passage of a steamer.

The following amount can be profitably expended upon the work during the present and next fiscal year, for providing the second of the two dredge-boats authorized by Congress:

Joint resolution, approved March 22, 1867	$275,000 00
Working expenses and repairs	100,000 00
	375,000 00

(See Appendices I, I 1, and I 2.)

Survey of the northwest channel from Key West to the Gulf of Mexico.

This survey was made in compliance with a letter from the Secretary of the Treasury, of January 29, 1868, enclosing from the Senate Committee on Commerce petitions from citizens of Key West, and of the city of New York, praying that surveys might be ordered and appropriations made for the improvement of this channel. Colonel and Brevet Brigadier General J. H. Simpson, corps of engineers, under whose direction the survey was made by Lieutenant William R. Livermore, corps of engineers, during the months of March and April last, concurs with the petitioners with regard to the importance of opening this channel by dredging, believing the project practicable.

He recommends opening a channel 300 feet wide, 18 feet deep, and 9,000 feet long, and estimates that for these dimensions about 262,800 cubic yards of material, a rather fine compact coral sand, will have to be removed. Owing to the exposed position of this channel, there will probably be not more than 90 working days in the year, from the necessity of having tolerably calm weather for the work. He therefore estimates that it would require four years for one steam dredge to complete the work, and the cost at about $166,000. Should two dredge-boats be employed, the work would be completed in half the time; but this estimate should be increased by the cost of the additional dredge, less some minor items, to, say, $217,000.

(See Appendix I A.)

SHIP CANAL AROUND THE FALLS OF THE OHIO, AND SURVEY OF THE TENNESSEE RIVER.

Officer in charge, Brevet Major General G. Weitzel, major corps of engineers.

1. *Survey and plans for a ship canal around the falls of the Ohio.*

This survey, provided for by resolution of Congress of March 29, 1867, was begun in July, 1867, and the special report thereon transmitted to Congress February 20, 1868.

The recommendation of the officer in charge, relative to the best route for a ship canal on the Indiana side, as to the manner and cost of completing the enlargement of the Louisville and Portland canal, and the construction of the two dams at the head and foot of the falls, were concurred in. For details of these plans see Appendix G.

Subsequently, and until the end of the present fiscal year, he has been engaged in arranging the details of the plans, and preparing specifications and drawings of the work.

In the course of these studies it was found that, in all probability, a

strong crib dam would be better than a masonry dam, across the crest of the rocks in front of Louisville, to raise the low water mark three feet. This change has accordingly been made in the plan.

A change has also been made in the lift of the lock, in the dam proposed to be built across the head of Falling-run pool. With these changes the engineer in charge submits the following estimates:

For Louisville and Portland canal extension	$933,500 00
For new canal on the Indiana side	3,470,000 00
For two dams and one lock	415,000 00
	4,818,500 00

If no new canal is built on the Indiana side the total would be as follows:

Louisville and Portland canal extension	$933,500 00
Two dams and one lock	310,000 00
	1,243,500 00
Required for next fiscal year	400,000 00

Under the allotment to this work from the recent appropriation General Weitzel has been authorized to construct the dam.

(See Appendices J, J 1, and J 2.)

2. *Survey of the Tennessee river, with a view to its improvement.*

The report of this survey was transmitted to Congress March 2, 1867, with estimates of the probable cost of the various plans recommended for the removal of the obstacles to the navigation of the river.

The several plans presented involve an expenditure of more than $4,000,000. They include, in addition to the removal of bars, ledges, and boulders, and the construction of wing and lateral walls, a canal of about 11 miles in length around Elk river shoals. Another of four and a half miles around the Little Muscle shoals, both to be 100 feet wide and six feet deep, with locks 300 feet by 70 feet, and the enlargement to the same dimensions of the old canal, built in 1835, by the State of Alabama, around the Muscle shoals.

The Elk river shoals, the two Muscle shoals, and Colbert's, all between Brown's ferry, 35 miles above Florence and Waterloo, 30 miles below it, are navigable for only one month in the year, and are then difficult and dangerous. They constitute the only formidable obstructions on the river below Chattanooga, and if overcome would open a navigation for nine months in the year throughout the whole length of the Tennessee river, and upon many of its tributaries. All other impediments are not insurmountable at most stages of the water.

The enlargement of the old canal being, therefore, of the first importance in connection with the removal of the obstructions in the river, General Weitzel suggests an appropriation of $500,000 for the next fiscal year to be expended upon that work.

Under the allotment to this river from the recent appropriations General Weitzel was directed to commence the works between its mouth

and Florence and between Chattanooga and Decatur. To complete these improvements there will be required for the next fiscal year $40,000.

(See Appendices J 3, J 4, J 5, J 6.)

IMPROVEMENT OF WESTERN RIVERS, EXCEPTING THE OHIO.

1. *Construction of snag-boats and machinery.*

Officer in charge Colonel J. N. Macomb, corps of engineers, having under his orders Brevet Major C. W. Howell, captain corps of engineers.

At the date of the last annual report the work upon these improvements was principally of a preparatory character. The three snag-boats, J. J. Abert, S. H. Long, and R. E. De Russy, were not launched until December last, as the water in the Ohio river was too low to admit of the launching at an earlier period.

The distinctive feature of these boats consists in having the machinery for pulling snags independent of that for driving the paddle wheels, and this has proved to be as important and useful as was anticipated.

The engineer in charge reports that the test fully realized his anticipations, and that the changes from the old plan have been found to be great improvements. The experience which has been gained since the commencement of the present working season shows where some improvements may be made in matters of minor detail, and justifies the adherence to the general plan and principle of the double hulled snag-boat with independent machinery for pulling snags.

Plans have been adopted for a light draught snag-boat for use upon the Arkansas river; proposals for the construction of which have been invited.

Advantage will be taken of the experience gained in the working of these boats in making more perfect such additional ones as may be needed hereafter. The operations of the three double hulled snag-boats, J. J. Abert, S. H. Long, and R. E. De Russy, have been attended with very good success.

The J. J. Abert was equipped and proceeded to her destination in March, 1868, and commenced operations in that part of the Mississippi river between St. Louis and Cairo, where all snags visible at the high stage of water then existing were destroyed; then proceeded down the river below Cairo, and removed and destroyed, up to the 30th of June, 1868, 158 snags in all, namely: above Cairo 103, and below that point, 55. These numbers convey a very inadequate idea of the labor performed. It may be better appreciated by the statement that the total weight of snags removed by the Abert is 2,708 tons, exclusive of the roots, of which no exact measure could be made.

The steamer S. H. Long proceeded, in April, 1868, to the Arkansas river, the field of operations assigned to this boat. On the way down the Ohio river a snag was successfully raised and destroyed. It had been a danger of long standing in the channel of the Ohio river, at the head of Wabash island. On her arrival at the Arkansas, the water was found at a very high stage; but after the stage of the water became more favorable for operations, there were removed and destroyed 134 snags; of which 108 were in the Arkansas river, and 26 were in White river cut-off. On the 20th of June, 1868, the water became too low for her safety in the Arkansas river, when operations were commenced in the Mississippi abreast of Ozark island, and were continued up the river towards Memphis. Up to the 30th of June, 1868, 14 large snags were removed and destroyed by this steamer in the Mississippi river. The total weight of snags removed up to the last named date by this steamer was 2,291 tons, exclusive of the roots.

The steamer R. E. De Russy proceeded to the Missouri river in May, 1868, and commenced operations at the mouth of the river, but owing to the high stage of water but eight snags were removed, when she proceeded up the river, and up to the 30th of June, 1868, there were removed and destroyed 222 snags, having left the river comparatively free from dangers for about 100 miles; the weight of the snags destroyed by this steamer is 2,486 tons, exclusive of the weight of roots. Before the close of the season 300 miles more of the Missouri will be cleared of snags, if the stage of water will admit.

Amount of funds available on commencing this work, under appropriation of June 23, 1866	$400,000 00
Amount expended to June 30, 1868	242,019 98
Leaving available July 1, 1868	157,980 02

which it is proposed to expend during the present fiscal year ending June 30, 1869.

Amount required for three additional snag-boats, and for repairs, &c., to June 30, 1870, $218,000, which can be profitably expended during the next fiscal year.

(See Appendices K, K 1 to K 12, inclusive.)

2. *Examinations and surveys on western and northwestern rivers.*

Brevet Major Howell, captain corps of engineers, made an exploration of the upper Missouri in the summer of 1867. In May of the present year he was directed to organize a party for the survey of the lower portion of the Missouri upon which duty he was engaged at the end of this fiscal year.

A party was sent in April last to the Arkansas river, to make examinations touching all the dangers to navigation in that river. From these examinations it is evident that a more minute survey of this river than has heretofore been made is necessary. This will be made without unnecessary delay.

(See Appendix K 13.)

3. *Improving the Mississippi, Missouri, and Arkansas rivers.*

The first work undertaken during the fiscal year for the improvement of these rivers was the removal, by blasting, of sunken wrecks, and other obstructions, in the vicinity of Memphis and St. Louis, and with better success at points upon the upper Mississippi.

The steamer Totten, which had been purchased and fitted up for this service, was unfortunately lost in December, by striking a snag, near Chester, Illinois.

She had met with good success, but had not the requisite strength of hull to sustain sufficiently powerful machinery for raising the heavy pieces detached from the sunken wrecks by explosion.

The engineer in charge is satisfied that the operations of wrecking can only be thoroughly accomplished by having a boat built expressly for such hard service.

Contracts were entered into for clearing snags, &c., from the Arkansas and Missouri rivers, with parties furnishing men, boats, and appliances. The reports of the agents appointed to supervise the work show a fair amount of work accomplished; nevertheless the engineer in charge reports that from his experience in these two contracts and the practical

working of the three new snag-boats, it is only by using government boats, expressly built, manned and fitted for this work, that such progress can be made as the nature of the work demands.

Amount of funds available on commencing this work, under appropriation of June 23, 1866	$366,666 00
Amount expended to June 30, 1868	154,161 00
Leaving available July 1, 1868	212,505 00

Which sum will be nearly expended during the present fiscal year ending June 30, 1869.

Amount estimated as required under this head for the fiscal year ending June 30, 1870	$290,395 00
From which deduct allotment from appropriation of act of July, 1868	85,000 00
	205,395 00

Required for next fiscal year, $205,000.

(See Appendices K and K 1 to K 12, inclusive.)

River channelers or excavators.

The Secretary of War having directed the examination of Colonel W. H. Noble's river dredging machine, the subject was referred to a board of engineers then in session upon the improvement of the rapids of the Mississippi.

The report of the board, which includes the examination of five other machines devised for the same object, (by, 1, C. E. Pierce; 2, Nelson Vandeventer; 3, E. B. Bishop; 4, Colonel S. H. Long; 5, E. P. Ligons,) will be found in Appendix K 14.

IMPROVEMENT OF THE OHIO RIVER.

In charge of W. Milnor Roberts, United States civil engineer.

The two surveying parties mentioned in the last annual report as being engaged upon the river continued their labors until the end of the season, when the high water and cold weather prevented their further progress.

There yet remains about 230 miles of the river, between Louisville and Cairo, to be surveyed. This will be completed during the present season.

It was expected that the several riprap dams, planned for the improvement of the low water navigation, would be finished before the close of the last season, but the almost unprecedented low condition of the river during the fall prevented the contractors at some of the places from moving the stone away from the quarries. Again, this spring, they were delayed by the high water stage continuing longer than usual.

At the date of this report all of the unfinished contracts were being pushed rapidly to completion. As a whole, it may be said the riprap dams have stood very well.

The engineer in charge estimates that $164,000 will be required at new points between Pittsburg and Louisville, where improvements are most urgently needed. In some parts of this distance communication between different points is confined altogether to the river, even in the worst periods of its navigation, so that the addition of a foot or more to the depth of the river would afford the means of using better boats for the transportation of freight, passengers, and mails throughout the year.

The plan adopted for the removal of obstructions in the river has proved successful. During the past season, those snags and wrecks which were most dangerous to navigation were removed for a distance of about 325 miles. The boulder rocks in the left channel of Brunot's island have been removed. Double crane boats and crews were attached to each steamer during the present season, and although the operations of removing obstructions were begun later than last year, it is hoped that, with this additional force and a favorable season, all the wrecks, trees, and snags known to be dangerous to the navigation of the Ohio will be removed before the winter sets in.

The estimate of the engineer in charge for continuing these improvements during the next fiscal year is $500,000 00
Amount required for next fiscal year $500,000 00
(See Appendix L.)

SURVEY OF THE POTOMAC RIVER.

A survey of the Potomac river, with a view to its improvement, was made under the direction of Major and Brevet Brigadier General N. Michler, corps of engineers, in accordance with the provisions of act of March 2, 1867, and a report thereon submitted.

In order to improve the navigation of the river, the causeway of the Long bridge should be removed, on account of its injurious effect upon the Washington channel; and it should, for the present, be replaced by a roadway upon piles, as the least expensive structure, until the expected advantage of such removal is fully proved. The bar in the Virginia channel should be dredged to a depth of 12 feet and a width of 200 feet, and the Washington channel should be deepened to the same depth, wherever needed, between the bridge and the mouth of the Eastern Branch.

General Michler's recommendation of a new cut between Easby's wharf and the Maryland draw of the Long bridge is deemed essential, with some modifications in its size and curvature, to restoring, as near as may be, the former navigable condition of the river. It should be wider, and at first need not be dredged to the full depth he recommends. A depth of eight feet at low water would be sufficient for the first work.

The obstructions in the vicinity of Easby's Point should be removed, but it is not deemed advisable to construct a breakwater or deflector across the Virginia channel, as recommended by General Michler. The effects of the dredging should be tested before any dikes are resorted to.

The estimated cost of these improvements is as follows:

1. For the removal of the causeway of the Long bridge, and to replace the same by a bridge upon piles	$25,000 00
2. For dredging the Virginia and Washington channels	8,000 00
3. For dredging a channel 8 feet deep and from 250 to 300 feet wide, between Easby's Point and the eastern draw of the Long bridge, say about 300,000 cubic yards	105,000 00
	138,000 00

(See Appendix V 4.)

IMPROVEMENT OF THE PATAPSCO, BELOW FORT M'HENRY, AND OF THE SUSQUEHANNA, BELOW HAVRE DE GRACE.

Officers in charge Brevet Major General J. G. Parke, major corps of engineers, from September, 1867, to June, 1868, and from that date Brevet Brigadier General J. H. Simpson, colonel corps of engineers.

1. *Improvement of the Patapsco river, below Fort McHenry, Maryland.*

The general result of the last year's operations has been the excavation of a channel from the Brewerton channel southward past the Belvidere shoal, having a general available width of 500 feet, at low water, for a length of five miles.

The result of this season's operations encourages the belief that this change of the direction of the dredged channel, proposed by Brevet Lieutenant Colonel Craighill, major corps of engineers, will prove a saving of distance and effect a permanent increase of depth.

Amount on hand July 1, 1867	$55,793 27
Amount since received	15,223 89
Amount expended to June 30, 1868	71,017 16
Amount allotted from the general appropriation	17,000 00
Amount required for next fiscal year	108,000 00

(See Appendix M.)

2. *Improvement of the Susquehanna river, below Havre de Grace.*

Since the date of the last annual report contracts have been entered into for all the labor and material required to complete this improvement so far as the present appropriation will admit.

The three cribs for the deflector were commenced in September, 1867, but owing to the delay in procuring long piles, they were not completed in time to admit of being entirely filled with stone. In consequence, two of them were so much injured by ice during the winter as to necessitate their reconstruction this spring. The construction of the rafts has progressed so far that they will soon be ready to be put in place. The engineer in charge anticipated that this improvement would be in working order by November 1 of this year.

It was found essential to remove, during the past season, some accumulations of sand formed by ice at the lower end of the dredged channel. About 30,000 cubic yards of material were removed by contract, giving a depth of eight feet at low water through the shoal, about two miles long. The effect of the deflector since its completion has established the sufficiency of this method of increasing the depth of water in the old channel. In view of this fact, the officer in charge deems it desirable that the temporary structure should be made permanent, the cost of which he estimates at $50,000. The amount required is recommended to be appropriated.

Amount on hand July 1, 1867	$26,400 00
Amount expended to June 30, 1868	22,899 05
Amount required for next fiscal year	50,000 00

(See Appendix M.)

CONSTRUCTION OF DELAWARE BREAKWATER AND IMPROVEMENT OF THE HARBORS OF MARCUS HOOK AND CHESTER; SURVEY OF REEDY ISLAND AND LISTON'S TREE POINT, DELAWARE BAY AND RIVER, AND EXAMINATION OF A SITE FOR AN INLET AT THE HEAD OF BARNEGAT BAY.

Officer in charge, Lieutenant Colonel C. S. Stewart, corps of engineers.

1. *Delaware breakwater.*

From July 1 to November 2, 1867, inclusive, labor was done by contract; but the contractor having failed to comply with his agreement,

and it being deemed impracticable, without great risk of material loss, to carry it on by contract, it has since that time been carried on by days' work.

During the working year 8,100 tons of stone were received and put in position, and 1,129 tons of old stone removed and relaid. A gap of 210 feet in length was closed at the breakwater proper, and an additional length of 228 feet of old work relaid and raised to the proper level.

At the ice-breaker 87 running feet of the superstructure were completed.

Amount expended during the year ending June 30, 1868..	$58,690 00
Liabilities incurred to June 30, 1868, yet unpaid.....	4,458 00
Net amount available for year ending June 30, 1869.....	150,002 35
Amount that can be profitably expended during the year ending June 30, 1869.....	70,000 00

No appropriation asked for.

(See Appendix N.)

2. *Harbor of Marcus Hook, Pennsylvania.*

A new wooden pier, about 31 by 41 feet, has been built on the ruins of the old pier-head of lower pier, and the ruined wharves and upper pier-head have been constructed anew.

Two bridges connecting pier-heads and wharves have been made, and all repairs satisfactorily completed by the contractor.

Three cribs for new piers have been built, two of them sunk in position, and a fourth is nearly ready to be put in place by the contractor.

Amount expended during the year ending June 30, 1868..	$26,446 50
Amount available July 1, 1868.....	71,715 52
Amount available to be expended during the year ending June 30, 1869.....	71,715 52

No appropriation asked for.

(See Appendix N 1.)

3. *Improvement of Chester harbor, Pennsylvania.*

The upper portions of upper and lower United States piers and wharves have been replaced; the upper bridges repaired; a new bridge built to connect lower pier-head and wharf; the lower causeway walls rebuilt for nearly its whole length of upwards of 612 feet, and a good roadway formed; the upper causeway was also repaired, and the piers and wharves have been well filled in. All contemplated repairs have been made.

Amount expended during the year ending June 30, 1868....	$10,647 14
Amount available July 1, 1868.....	352 86
Amount profitably to be expended during the year ending June 30, 1869.....	352 86

No appropriation asked for.

(See Appendix N 2.)

4. *Survey of Reedy island*

has been completed and reported upon.

(See Appendix N 3.)

5. *The survey of Liston's Tree Point*

has also been completed and reported upon.

(See Appendix N 4.)

6. *Examination as to the necessity of opening an inlet on the New Jersey coast, from the Atlantic ocean, at a point near the head of Barnegat bay.*

In compliance with a resolution of the House of Representatives, of February 4, 1868, this examination was made by Lieutenant Colonel Stewart in April last. He is of opinion that there is no necessity, for the purposes of commerce, for the proposed inlet, and that if made it could not in all probability be kept open.

On this point his conclusions are doubtless correct. The breaches that have occasionally occurred across the beach separating Barnegat bay from the ocean are reported to have always closed after a short interval, showing that ordinarily Barnegat inlet is sufficient for the discharge out of Barnegat bay, and that should a new cut be made there would not, in all probability, be a sufficient outflow to maintain it. On the other hand, if kept open it would probably have an injurious effect upon the inlet at Barnegat.

The information gathered upon this subject not being from a detailed survey, was necessarily meagre. Should the interests of navigation or commerce require a more exact discussion of the question, the requisite data should be carefully collected.

(See Appendix N 5.)

7. *Obstructions to navigation in Delaware bay.*

A special report was made June 24, 1868, in relation to the removal of the wrecks, as obstructions to navigation, and a recommendation made therein for an appropriation of $6,000 for the purpose indicated.

(See Appendix N 6.)

HUDSON RIVER IMPROVEMENT; REPAIRS OF UNITED STATES DIKES ABOVE AND BELOW ALBANY; CONSTRUCTION OF NEW DIKES; SURVEY OF THE RIVER; REMOVAL OF OBSTRUCTIONS IN NEW YORK HARBOR.

Officer in charge, Brevet Major General John Newton, lieutenant colonel corps of engineers, assisted by Brevet Lieutenant Colonel John M. Wilson, major corps of engineers.

1. *Hudson river improvement.*

A new dike between Albany and Troy, connecting upper Patroon and Hillhouse islands, 2,920 feet long, was undertaken and finished early in December, 1867. The cost of this dike was $7 40 per lineal foot.

The shore line of Hillhouse island for a length of 1,908 feet, equivalent to a surface of 7,225 square yards, was graded and paved with blocks of stone, at a cost of $2 20 per square yard.

Below Albany, to restore and repair the old United States dike, commonly called the Overslaugh dike, 2,531 lineal feet of half dike were constructed at the rate of $9 80 per foot, and 7,200 lineal feet of old dike repaired by filling up existing abrasions and repairing surface, viz: a surface amounting to 24,975 square yards was refilled at a cost of $2 82½ per square yard, the excess in this case being due to the large amount of filling required.

The cutting away of the face of Mull's island, opposite Barren island, was undertaken at a cost of 21 cents per cubic yard, and the dredged materials deposited behind the New Baltimore dike at the contractor's expense.

The contractor commenced this work in September, 1867; suspended work at the close of navigation; resumed in April, 1868, and by June 30 had removed 169,948 cubic yards. This work is still continued.

In May, 1868, work was commenced at and opposite Cedar Hill, just above Castleton, upon two dikes—one joining Cow and Campbell islands, 2,500 feet long; the other leading from Cedar Hill dock to Schemerhorn island, 5,650 feet long.

The contractor for furnishing piles has caused great delay in the construction of these works, by failing to fulfil his contract, but by June 30 there had been driven in the Cow Island dike 37,258 lineal feet of piles, and 50,576 lineal feet at the Cedar Hill dike.

2. The survey of the river between Troy and New Baltimore.

Was continued and nearly completed by June 30, 1868, to determine the rise and fall of tides. Lengthened observations were made at Troy, Albany, Castleton, Coeymans, and New Baltimore. Observations, during the operation of sounding, were likewise made between Albany and Troy at the wharf of the nail works, and at the upper end of Patroon's island.

A line of levels was run from Troy to New Baltimore, connecting all the places where tidal observations were made, and bench marks were established.

Superficial current velocities were ascertained during the course of the ebb.

Observations were likewise made upon the bottom for the purpose ot testing the movement of the material of the bed.

An allotment for continuing this work, from the general appropriation, was made of $85,000. Amount required for next fiscal year, $160,000. (See Appendix O.)

3. East river, New York harbor.

Three separate projects for the improvement, with channels of 26 feet, and 24 feet in depth at mean low water, were submitted by General Newton, corps of engineers.

The first includes the removal of all the rocks enumerated, the construction of sea walls, improvement of the middle channel, and the removal of Negro Head.

The second includes the cost of removing that part of middle reef known as Negro Head, Hen and Chickens, Flood Rock, and Gridiron, thus throwing the eastern and middle channels into one.

The third includes the removal of the smaller rocks and the construction of the sea walls, but makes no provision for improving the middle channel, or otherwise interfering with the middle reef.

The last project, involving the least expenditure of money, and greatly ameliorating the danger to navigation, essentially recommended in 1856 by the advisory council to the commissioners, relative to the encroachments and preservation of the harbor of New York, has been recommended by me as the best to be undertaken at present.

The advisory council referred to consisted of General Totten, Chief of Engineers United States army, Dr. A. D. Bache, Superintendent United States Coast Survey, and Commander (now Admiral) Charles Henry Davis, United States navy.

The estimate for the project at Hell Gate, giving a channel of 26 feet at mean low water, is	$2,877,000 00
General Newton's estimate for removal of Diamond and other reefs in East river, New York harbor, to 24 feet depth is	463,145 00
Total	3,340,145 00

There has been allotted, of the general appropriation for repairs, preservation, &c., to the improvement of the East river, $85,000.

The amount required for the next fiscal year is $415,000.

(See Appendices O 1 to O 6, inclusive.)

IMPROVEMENT OF PROVIDENCE AND PAWTUCKET RIVERS, RHODE ISLAND, THAMES RIVER, CONNECTICUT; REMOVAL OF MIDDLE ROCK, NEW HAVEN HARBOR, AND WESTPORT HARBOR, CONNECTICUT; SURVEYS AT BLOCK ISLAND, RHODE ISLAND, CONNECTICUT RIVER AND BRIDGEPORT HARBOR, CONNECTICUT.

Officer in charge, Major and Brevet Colonel D. C. Houston, corps of engineers United States army.

1. *Improvement of Westport harbor, Connecticut.*

The amount of the appropriation for this work, $2,500, being entirely inadequate, no work has thus far been accomplished.

The sum of $10,000 was asked for last year.

(See Appendix P.)

2. *Removal of Middle Rock, New Haven harbor, Connecticut.*

The work of removing this rock was suspended in September last, owing to the appropriation being nearly exhausted.

The depth of water on the rock was increased from nine feet, at low water, to 15 feet.

The plan adopted, viz: by drilling holes in the rock and exploding cartridges of powder in them by means of a battery, was very successful.

Total amount expended	$5,686 69
Amount available June 30, 1868	250 56

To secure a depth on this rock of 17 feet, as originally proposed, will require	$10,000 00
To remove southwest ledge, near Middle rock, on which is now 6½ feet at low water	30,000 00
To remove to the same depth two rocks between these two	25,000 00
Total required for "removing rocks in New Haven harbor"	65,000 00

(See Appendices P and P 1.)

3. *Survey of Connecticut river from Hartford to its mouth.*

A survey of this river with a view to its improvement was made last season.

There is a number of bars on this river between Hartford and Middleton, which are serious obstructions to navigation in the season of low water. The bar at the mouth of the river is also an obstruction.

From the character of the river, which passes through an alluvial

region, no permanent structures are recommended for its improvement. Some years ago piers were constructed for the purpose of confining the channel, but at present these piers are either obstructions in the river or are covered up by deposits.

The plan recommended is to deepen the water on the bars by dredging or scraping. It is estimated that the sum of $70,000 will suffice to give the depth required, *i. e.*, 8 feet at lowest water on record, and that the sum of $10,000 expended annually will suffice to maintain this depth.

(See Appendices P to P 3 to P 6.)

4. *Improvement of Thames river, Connecticut.*

The work on this river has consisted in deepening the channel below the city of Norwich to obtain a depth of 14 feet at high water.

The total amount of material excavated up to June 30, 1868, was 67,201 cubic yards, mostly sand and gravel. The work has been prosecuted with a view to immediate benefit to navigation by first deepening and straightening the channel at the most difficult points, and thus far has given satisfaction to navigators. It is proposed to obtain a channel 100 feet in width, of the depth above mentioned. Immediately below the mouth of the Shetucket river at its junction with the Quinnebaugh, the channel has been widened to 200 feet, so as to allow a free passage for the ice which accumulates here in large quantities.

Total expenditure during the fiscal year ending June 30, 1868	$33,139 35
Amount available June 30, 1868	47,918 40

No further appropriation required.

(See Appendices P and P 2.)

5. *Improvement of Providence river, Rhode Island, at the "Crook."*

The work during the year in this river consisted in dredging the channel at the "Crook." Total amount of material excavated 1,781,560.6 cubic feet.

Total amount of disbursements under this appropriation, $25,000, which was the amount of the appropriation. The engineer in charge reports that the sum of $10,000 per annum could be advantageously applied in dredging the channel of this river below the Fox Point wharf.

Required for next fiscal year, $10,000.

(See Appendix P.)

6. *Improvement of Pawtucket river, Rhode Island.*

The work during the year on this river consisted in dredging the channel, to obtain six feet depth, at low water, up to the city of Pawtucket.

The amount appropriated, $17,000, was found insufficient to complete the work, for which the officer in charge estimates that an additional sum of $8,000 will be necessary.

This amount is required for the next fiscal year.

(See Appendix P.)

7. *Survey at Block island, Rhode Island.*

A survey of the vicinity of this island with a view to the construction of a breakwater to form an artificial harbor was made last season.

A project for a breakwater, both for local and general use, has been submitted. The estimated cost is $1,500,000.

(See Appendices P 7 and P 8.)

8. *Survey of Bridgeport harbor, Connecticut.*

A few soundings were made in this harbor last season for the purpose of ascertaining what change, if any, has occurred since the survey of 1866. No material changes were discovered. It has been apprehended that this harbor would be filled up by deposits of sand brought in by the flood tides; and a resurvey is now in progress which will determine precisely what changes, if any, have occurred since 1866, and indicate the proper remedy for any injury that the harbor may have sustained.
(See Appendix P.)

PLYMOUTH BEACH AND TAUNTON RIVER, MASSACHUSETTS.

Officer in charge, Brevet Major J. A. Smith, captain corps of engineers.

1. *Plymouth beach.*

No additional work has been done at this locality during the year.
An allotment of the general appropriation of 1864 has been made to this work, of $7,500. Amount required for the next fiscal year, $8,000.
(See Appendix Q.)

2. *Taunton river.*

For report and estimate for the improvement of this river see appendix Q 1.

PRESERVATION AND IMPROVEMENT OF BOSTON HARBOR.

Officer in charge, Brevet Major General J. G. Foster, lieutenant colonel corps of engineers.

1. *Dredging off the southwest point of Lovell's island.*

The work has been prosecuted with vigor by the contractor, who has removed 92,899 cubic yards, widening the channel at this point to 820 feet at low water, with an average depth over the dredged area of 13 feet at low water.
A larger and more powerful dredging machine is being built, and is nearly completed, intended to excavate over the dredged area to a depth of 23 feet at low water.
(See Appendices R, R 1 to R 5, inclusive.)

2. *Dredging channel across the Upper Middle bar.*

Owing to the failure of the first contractor to enter upon the work, it had not been commenced at the close of the fiscal year. It is now in progress.
(See Appendices R, R 1 to R 5, inclusive.)

3. *Blasting and removing Tower and Corwin rocks.*

This work has been successfully carried on and has resulted in the entire removal of Tower Rock to a depth of 23 feet at mean low water. Corwin Rock has been blasted down to a depth of 21½ feet at mean low water. It is intended to remove Corwin Rock to a depth of 23 feet at mean low water, and also to blast off and remove to the same depth an adjoining ridge of rock.
(See Appendices R, R 1 to R 5, inclusive.)

4. *Sea wall at Point Allerton.*

As no funds were available for the purchase of the site for this wall, an appropriation by the Commonwealth of Massachusetts was procured for the purpose of purchasing the narrow strip of land at the high-water line, necessary for the foundation of the wall, with the shoals in front and slopes in rear, to be transferred to the United States in fee simple. As soon as the question of title is settled the purchase and transfer to the United States may be made and the work commenced.

(See Appendices R, R 1 to R 5, inclusive.)

5. *Sea wall for preservation of Gallop's island.*

The city of Boston, which owns this island, has given to the United States the strip of land upon which to build this wall with the shoals in front and slope in rear, together with the use of the necessary amount of land for temporary buildings, wharf, &c., to be used in the construction of the wall. All the preparations for the commencement and rapid prosecution of the work having been completed, the work is now under construction.

(See Appendices R, R 1 to R 5, inclusive.)

6. *Sea wall for the preservation of the north head of Long island.*

The work has not been commenced; steps have been taken to secure the title to the United States of the site for this work, and for the military defences to be erected on Long Island, north head. For this purpose an act has been passed by the legislature of the Commonwealth, providing for the determination by the county court of the amount to be paid the owners, and for the vesting of the requisite title in the United States upon deposit of said sum in the hands of the judge of the court.

(See Appendices R, R 1 to R 5, inclusive.)

Estimates for the next fiscal year for continuing the preservation and improvement of Boston harbor.

For Corwin Rock	$24,000 00
Dredging Great Brewster and Lovell's Island spits	100,000 00
Dredging Upper Middle bar	50,000 00
Preservation of north head of Long island	75,000 00
Preservation of Gallop's island	54,000 00
Preservation of Point Allerton	21,000 00
Total	324,000 00
Less amount of allotment assigned to these works	33,000 00
Amount required to be appropriated for the next fiscal year	291,000 00

PROPOSED BRIDGE FROM BOSTON TO EAST BOSTON.

The Committee on Commerce, of the Senate, requested the views of the Secretary of War upon the propriety of authorizing the construction of a bridge between Boston and East Boston.

The report of Brevet Major General Foster, in charge of the improvement of Boston harbor, to whom this subject was referred, will be found in Appendix R 7.

PRESERVATION OF PROVINCETOWN HARBOR, CAPE COD, MASS.

Officer in charge, Brevet Major General H. W. Benham, colonel corps of engineers, to June 22, 1868; since that date Brevet Major General J. G. Foster, lieutenant-colonel corps of engineers, having temporarily under his orders Brevet Major George Burroughs, captain corps of engineers.

Preservation of Provincetown harbor.

At Long Point the aproning of stone near the light-house has been extended to the eastward during the summer; several hundred tons of stone have been thus deposited with favorable results, as they maintain their position and afford an efficient protection to the beach.

At Beach Point preparations are being made to repair the injuries done to that narrow strip of beach by a storm in April of this year. Plans of a brush bulkhead and jettees for this purpose have been prepared and work has been commenced upon them.

As there were grounds for apprehending that during some great storm the sea might make a breach through the sand ridge on the outer or sea beach into East harbor, the engineer in charge is constructing a dike across the salt meadows and East Harbor creek, at a narrow point called the "wading place," opposite High Head.

Observations for determining the currents and the nature and extent of the changes in Provincetown harbor are now being made under the immediate direction of Captain George Burroughs, brevet major United States army.

(See Appendices R, R S, R S 1 and R S 2.)

SEA WALLS AT GREAT BREWSTER, DEER, AND LOVELL'S ISLANDS, BOSTON HARBOR.

Officer in charge, Brevet Major General H. W. Benham, colonel corps of engineers.

1. *Deer and Lovell's islands.*

On Deer island a contract was entered into in April last for rebuilding the North Head wall. The entire work of the fiscal year has been the reconstruction of about 200 lineal feet of wall on the middle head, about 420 lineal feet on the south head, and about 206 lineal feet on the north head; or in all 826 lineal feet during the year.

On Lovell's island the greater portion of the cut stone and a part of the jetty stone for this wall have been delivered and distributed along the site of the work.

At the close of the fiscal year operations were about to commence under the contract for the construction of this wall.

Amount on hand for both works, July 1, 1867	$84,529 30
Amount expended during the fiscal year to June 30, 1868..	32,029 05

(See Appendix S.)

2. *Great Brewster.*

At the date of last report the wall for the protection of the south head of this island had been completed, and on the east or north exposed face of the north bluff the main wall was about finished except paving in rear.

During the rest of the season of 1867 the main wall of the north head, with its coping, was completed as far as intended in the original design; that is, as far as the bluffs or slopes of the shore show signs of recent abrasion by the sea.

The extent of wall constructed during the fiscal year is 550 lineal feet.

The work still to be done comprises filling the unbacked portion of the wall with earth, setting heavy paving on the most exposed parts of the east faces, and protecting the gap between the north and west walls.

The officer in charge renews his recommendation of last year, that the two main walls be connected, to prevent the continual wearing action of the sea upon the beach between them. For which he deems $25,000 will be sufficient, if done by hired labor.

Amount on hand July 1, 1867	$41,161 25
Amount expended during the year ending June 30, 1868	40,343 75

The sum of $10,000 of the allotment to Boston harbor was assigned to this work, which, deducted from the estimate, leaves to be appropriated for the next fiscal year $10,000.

(See Appendix S.)

IMPROVEMENT AND SURVEY OF RIVERS AND HARBORS IN THE STATE OF MAINE.

Officer in charge, Brevet Brigadier General George Thom, lieutenant colonel corps of engineers.

1. *Improvement of Saco river.*

This work consists in the construction of a breakwater at the mouth of the river, the removal of sunken rocks, and the rebuilding of some of the most important piers in the river. Two thousand five hundred and fifty lineal feet of the breakwater have been partially built, and carried up to a general level of ten feet above mean low water, or one foot above mean high water. One large sunken rock has been removed from the channel of the river opposite to Little island.

Estimated cost of the breakwater, with its proposed extension, together with the other improvements in the river	$320,000 00
Total amount appropriated in 1866 and 1867	80,000 00
Amount still required for the completion of the improvement,	240,000 00
Of which there can be profitably expended during the next fiscal year	75,000 00

(See Appendix T.)

2. *Extension of breakwater in Portland harbor, Maine.*

Operations during the past year have been confined to capping the present breakwater, of which 538 lineal feet have been built, nearly completing it. The project for its extension has not been decided on, it having been found advisable, before doing so, to make a resurvey of the harbor, as well as careful tidal and current observations, which have been completed.

Under a joint resolution of Congress a part of the appropriation is to be applied to improving the harbor by dredging and otherwise.

The amount appropriated is deemed sufficient for the completion of the breakwater, and other improvements called for.

(See Appendices T 1 and T 5, inclusive.)

3. *Improvement of Kennebec river, between Shephard's Point and Augusta, Maine.*

This work consists of straightening and deepening the channel of the river, by dredging through several shoals. The width of the channel, according to the original plan of General Thom, was 75 feet at bottom, with sides having a slope of two feet to one foot rise, and a depth of

seven feet up to Hallowell, and six feet thence to Augusta, in the lowest stages of the water. This width, however, General Thom finds to be insufficient, and recommends that it be increased to 100 feet at bottom. A contract for the work to the extent of 100,000 cubic yards of dredging was made, and it is probable will be completed during the present season,

Amount required to open a channel 100 feet wide, from Gardiner to Shepard's Point, (see survey of Kennebec river,) and to increase the width of the channel thence to Augusta, (in addition to the sum heretofore appropriated).. $30,000 00

(See Appendices T 6 and T 7.)

4. *Improvement of the navigation of St. Croix river, above the "Ledge."*

For this improvement it will be necessary to deepen its channel by the removal of slabs, edgings, and saw-dust, which for 30 years and more have been accumulating in large quantities in the river.

The act making an appropriation for this improvement requires the co-operation of the province of New Brunswick, which has not yet been obtained, so that operations have not been commenced.

Amount appropriated for this work..... $15,000 00
Additional amount required for its completion..... 35,000 00

It being understood that the province of New Brunswick will contribute an equal amount for this purpose.

(See Appendix T 8.)

5. *Survey of Kennebec river, above Gardiner, Maine.*

This survey has been completed, and estimates made for the improvement of the navigation by dredging a channel 100 feet wide at bottom. See improvement of Kennebec river for estimate.

(See Appendix T 9.)

6. *Survey of Penobscot river, above Hampden, Maine.*

This survey has been completed. Very extensive accurate soundings and borings made in the river show that from Crosby's narrows up to Bangor, a distance of some three and a half miles, the bed of the river is seriously obstructed with slabs, edgings, and saw-dust to an average depth of 10 feet, and in some localities more than 18 feet; and that the harbor of Bangor is also obstructed with several large sunken rocks. To restore the channel to the original river-bed would require an excavation of more than 5,000,000 cubic yards of its accumulations. But a passable channel could be made at a cost estimated at from $100,000 to $500,000, according to its width and depth.

(See Appendix T 10 to T 13, inclusive.)

RIVERS AND HARBORS ON THE PACIFIC COAST.

Officer in charge, Brevet Lieutenant Colonel R. S. Williamson, major corps of engineers, who has under his orders First Lieutenant W. H. Heuer, corps of engineers.

1. *Improvement of Willamette river, below the city of Portland, Oregon.*

The operations on this river during the past fiscal year have been confined to dredging on Swan Island bar, and removing snags at that point as well as at the mouth of the river.

Owing to the necessity of repairing the dredging machines loaned by

the city of Portland, the work was not commenced until September 10, 1867. From that date to the end of November, when the work was stopped by high water, 18,184 cubic yards of material were removed, at a cost of $10,484 48, being an average of 57.6 cents per cubic yard.

By this excavation a channel was made 100 feet wide, 900 feet long, and 15 feet deep at extreme low water. The average depth of the excation was 4.18 feet. Work was resumed on the 20th February, and continued to the 11th April, during which time 331 lineal feet of channel of the same width and depth was excavated, by the removal of 7,320 cubic yards of material, at an average depth of 5.9 feet, costing $4,607 19, being an average of 62. 9 cents per cubic yard.

Seventeen feet can be carried at the lowest stage in the Columbia river, below the mouth of the Willamette, and 19 at the highest, hence the officer in charge recommends that the channel of the Willamette at Swan Island bar be deepened to 18 feet, as originally intended. To dredge a channel of that depth would require the removal of about 50,000 additional cubic yards of material, at a cost of $31,200. A survey of the mouth of the river will be necessary before the extent of the excavation required at that point can be ascertained.

It appeared from a survey made after the November rise that the winter freshet caused no material change or filling up of the channel.

Amount on hand available July 1, 1867	$29,000 00
Amount expended during fiscal year	25,284 49
Amount allotted from general appropriation of 1868	21,000 00
Required for next fiscal year	15,000 00

(See Appendices U, U 1, and U 2.)

2. *Removal of Blossom and Rincon rocks in the harbor of San Francisco.*

Minute surveys were made of these rocks by the Coast Survey some years ago, and in the summer of 1866 the board of underwriters, with others interested, caused some experiments to be made on Rincon rock to test the practicability of removing it by blasting, the result of which was an estimate that its removal would cost about $65,000.

Blossom rock is in a much more exposed situation. Lieutenant W. H. Heuer, corps of engineers, experimented upon this rock in the winter of 1867 by removing, by blasting, some 69 cubic yards of stone, to form an estimate of the probable cost of such work.

From his results it is estimated that $60,000 will probably be required for its entire removal. An allotment of $50,000 has been made from the appropriation of July last for this object.

Amount required to be appropriated for the next fiscal year, $10,000.

(See Appendix U 3.)

3. *San Diego harbor, California.*

A special report was made June 22, 1868, in compliance with the request of the chairman of the Committee on Commerce, United States Senate, dated June 5, 1868. The report is herewith submitted.

(See Appendix U 4.)

SURVEYS AND EXAMINATIONS ON THE PACIFIC COAST.

Survey of the Upper Columbia river, Oregon.

The object of this survey is to ascertain the size and position of sunken rocks in the several rapids of the river, with the view of forming an estimate of the cost of their removal.

Between the Dalles of the Columbia and the mouth of Snake river there are six rapids, from which rocks should be removed to secure a depth of seven feet at the lowest stage of water.

Four of these rapids have been surveyed during the fiscal year, from which it is found that 4,726 cubic yards of rock must be removed by blasting. Upon the remaining two rapids, not yet surveyed, it is thought that about 650 cubic yards of rock must be removed.

It is proposed to make trials upon some of these rocks to obtain data for forming an accurate estimate of the cost of blasting. From the best information now in his possession, the officer in charge estimates it at about $28 per cubic yard, making at that rate the whole cost $132,328.

(See Appendix U 2.)

Point Sal, California.

The report upon the survey for an artifical harbor at this locality will be found in Appendix U 5.

SURVEYS AND EXAMINATIONS WITH THE VIEW TO THE IMPROVEMENT OF RIVERS AND HARBORS.

The following estimates af appropriation are submitted, showing the amount required for the purpose of making further surveys and examinations of localities, the improvement of which has been heretofore, or that may be hereafter, authorized.

For the Atlantic coast	$30,000 00
For the Pacific coast	25,000 00
For the western and northwestern rivers	125,000 00

PUBLIC BUILDINGS, GROUNDS, AND WORKS IN THE DISTRICT OF COLUMBIA, AND WASHINGTON AQUEDUCT.

Officer in charge, Brevet Brigadier General N. Michler, major corps of engineers.

For the condition of the public works within the District, and suggestions for such further improvement as appears necessary for the public service, the health of the inhabitants, and the proper arrangement of the public grounds, see report in detail.

(Appendices V and V 2.)

Required for next fiscal year, $526,000.

The recommendations in the report of last year are renewed.

Washington aqueduct.

A report in detail upon the work done during the year, and upon the condition of the finished portions, will be found in Appendix V 1.

The engineer in charge recommends an appropriation for the rent and purchase of the land occupied by the aqueduct, to which the United States have no title; and gives estimates in detail for the entire completion of the work, amounting to $685,338, which is required for next fiscal year.

SURVEY OF THE NORTHERN AND NORTHWESTERN LAKES.

Officer in charge, Lieutenant Colonel and Brevet Brigadier General W. F. Raynolds, corps of engineers, assisted by Captain and Brevet Lieutenant Colonel F. U. Farquhar, and Lieutenants J. F. Gregory,

B. D. Green, E. H. Ruffner, J. C. Mallery, J. E. Griffith, W. E. Rodgers, and L. M. Haupt, corps of engineers; and principal assistants D. F. Henry, O. N. Chaffee, J. R. Mayer, and H. Gillman.

During the summer of 1867 three steamers, five shore parties, and one astronomical party, divided into three sections, were engaged on Lake Superior in connecting previous surveys at the head of St. Mary's river and Marquette; in making the topographical and hydrographical survey of Isle Royale; in carrying the primary triangulation from Keweenaw Point to the eastward, including the whole of Keweenaw bay, and in the measurement of the large triangles connecting the north and south shores of Lake Superior.

Two small parties, for the purpose of gauging the outflow of the lakes, were stationed during the first part of the season at Sault St. Marie and St. Clair; and in the latter part of the season were transferred, the one to Fort Niagara, the other to Ogdensburg.

The summer's field work was plotted during the winter, and comprised 24 sheets of antiquarian, embracing 3,381 square inches of topography and 4,086 square inches of hydrography.

The new base line near Portage City, five miles long, was measured.

During the year 6,854 charts of the lake survey were distributed.

Two detail charts—one of the south end of Green bay, on a scale of one to one hundred and twenty thousand; and the other of the north end of Lake Michigan, including the Straits of Mackinac and Green bay, on a scale of one to four hundred thousand—are now in the hands of the engraver.

A preliminary chart of the south shore of Lake Superior from Grand island to Ontonagon was engraved on stone at the office of the survey.

A chart of Lake Superior from Grand island to Ontonagon is now being reduced for publication.

A preliminary chart of Lake Superior from the St. Mary's river to Grand island is being reduced on stone.

During the summer of 1868 the operations of the survey were in progress, with the following organization, namely: three steamers on Lake Superior; five shore parties on Lake Superior; three astronomical parties, one at Ogdensburg, one at Watertown, and one at Oswego, New York; three gauging parties, measuring the outflow of the rivers St. Clair, Niagara, and St. Lawrence; thirteen meteorological observers at different localities on the lakes; two draughtsmen reducing maps for publication; two assistants in office and attending to chart distribution; three assistants engaged in reducing meteorological observations, &c.

It is believed that the operations of another season will complete the survey of Lake Superior, there now remaining to be surveyed the immediate vicinity of Bayfield and La Pointe, comprising about 80 miles of the south shore and the Apostle islands, together with the primary triangulation of the lake.

The amount available during the present year, which will be exhausted by June 30, 1869, is the partial appropriation of March 2, 1867, withheld but re-appropriated, of..	$75,000 00
And the amount appropriated July 25, 1868.....	75,000 00
Total appropriated.....	150,000 00

The amount required for continuing the survey during the year ending June 30, 1870, is..... $165,000 00

(See Appendix W.)

RECONNAISSANCES AND EXPLORATIONS.

1. *Military division of the Pacific.*

The officer on duty in this division, Brevet Lieutenant Colonel R. S. Williamson, major of engineers, reports that two assistants have been engaged in the State of Nevada, who accompanied the party sent out by the State geologist of California, by which means much additional information has been collected, which has enabled him to prepare a map of a large portion of that State, which is now on the records of the headquarters, and is used for perfecting that portion of the general map of the country west of the Mississippi river.

Colonel Williamson has also been for many years occupied with observations and investigations with a view to improving the methods of measuring heights with the barometer. The result of these investigations has been lately published, for the use of the corps of engineers.

(See Appendix U.)

2. *Colorado of the West.*

The resumption of the explorations of the Colorado of the West, beginning at the locality where the War Department exploration terminated, a few miles below the Mormon settlement of Callville, the present head of navigation, being deemed of much importance, Brevet Lieutenant Colonel Williamson and Brevet Lieutenant Colonel Mansfield were directed to prepare and submit projects for the exploration of the river, including its chief upper tributaries. For their reports

(See Appendices X, X 1, and X 2.)

3. *Explorations from the Sierra Nevada to the Rocky mountains.*

The geological and topographical exploration of the territory between the Rocky mountains and the Sierra Nevada mountains, including the route or routes of the Pacific railroad, under the direction of Mr. Clarence King, has progressed very satisfactorily. The exploring party examined, during the summer of 1867, the first season in the field, a section of country extending from the 120th meridian eastward to longitude 117° 30′, and reaching from latitude 39° 30′ to 41°, which Mr. King reports has been attended with difficulties and dangers. The entire party had been disabled by malaria. The great flood of the previous spring left a large amount of stagnant water, the miasma from which has been fatal to the inhabitants of the desert. Mining and gold milling operations were in consequence suspended at the Humboldt sink. Mr. King reports that he reached the field July 27, 1867, marked out the limits of the year's work, which were completed with the exception of 40 miles of the eastern end. He estimates that at least 20 per cent. of the effectiveness of the party was destroyed by the prevalent fevers.

In amount and quality of work it fully meets his expectations.

The entire section has been covered by a series of triangles. Astronomical observations were made at four stations.

In geology the work has been thorough, and the results of great economical and scientific value. Materials have been obtained for describ-

ing the mineral wealth and for the discussion of the higher questions of orographical dynamics. Two thousand specimens of this branch have been obtained, illustrating every rock formation in the section surveyed.

Barometrical observations have been made at 300 stations, and over 2,000 observations made in the department of meteorology. The rate of evaporation has been determined at the sinks of the Humboldt and Carson.

The winds have been well studied and the results in this whole branch are of value.

The natural history will produce more novel results than any other branch.

During the winter Mr. King and one assistant were engaged in the examination and survey of the Comstock silver lode. The ores collected in the Black Rock mining district were analyzed by another assistant. The topographical surveys were plotted by the assistants in that branch. Gratifying progress has been made in the study of the mining district, and it is hoped that the results of the investigations will be of great value as illustrating both the geological occurrence of silver and some points of importance in the economical bearing of silver mining.

The field-work was resumed at an early period in the spring, and the section of the country as far east as Salt Lake city will be completed by the close of October of this year, including all the mining surveys of the Great Basin, and the silver mines of South Idaho.

An assistant has also been sent forward to make engineering studies of the Colorado mines.

At the date of the last report from Mr. King the work of this season had progressed with gratifying success; and it is believed that the entire field-work will be completed by the close of this season.

4. *Military division of the Missouri.*

The officer on duty in this division, Brevet Colonel W. E. Merrill, major of engineers, reports that he has been occupied with the preparation of maps and sketches for the use of the division, of the department, and posts. His report is appended hereto.

(See Appendix X 3.)

5. *Military departments of the Missouri, Platte, and Dakota.*

An officer of the corps of engineers has been on duty during the season of field operations in each of the military departments of the Missouri, of the Platte, and of Dakota, subject to the orders of the department commander. Their duties have chiefly been comprised in reconnaissances, and the preparation of sketches and maps, and their distribution within the commands to which they were attached.

No special reports have been received from these officers except from the officer on duty in the department of the Platte. His report of the last season's operations is appended hereto.

(See Appendix X 4.)

6. *Maps of the territories, military departments, and posts.*

The re-compilation of the map of the territory between the Mississippi river and the Pacific ocean has progressed as rapidly as the information

could be collected and prepared for engraving. The valuable results of the labors of the northwest boundary commission were continuously furnished by the commissioner, Mr. Archibald Campbell, and were used in the compilation; also the surveys at the headwaters of the Yellowstone and Missouri rivers, by Brevet Brigadier General W. F. Raynolds, corps of engineers, and information furnished by Generals Warren and Comstock, have been used.

Much additional information has lately been received from Colonel R. S. Williamson, corps of engineers, which embraces portions of California, Nevada, Idaho, and Arizona.

The general map of the country west of the Mississippi river, defining the military departments and posts, is kept in progress with the foregoing. An edition is issued with corrections and additions from time to time, as the map is called for, to meet the wants of the military forces occupying the country.

MAPS OF CAMPAIGNS AND BATTLE-FIELDS.

The surveys of the fields of operations during the war, and of the battle-fields, as well as the maps of the surveys, have been continued, and they are well advanced towards completion.

Those of the campaigns of the army of the Potomac have been under the direction of Brevet Brigadier General Michler, corps of engineers, and those of the western armies under the direction of Colonel Edmund Ruger, late of the volunteers. The general map illustrating the campaigns of Lieutenant General Sherman, in progress at the date of the last annual report, has been finished.

The general map illustrating the campaigns of Major General George H. Thomas is nearly completed.

(See Appendix X 5.)

ESTIMATES OF SURVEYS FOR MILITARY DEFENCES.

The appropriation for surveys for military defences is now nearly exhausted.

For surveys relating to permanent sea-coast defence, explorations, surveys, and reconnaissances in the interior, including that of the Colorado river, and the collection of topographical and other information of the country occupied by military forces; for the compilation, engraving, printing, and distribution of maps, including campaign maps, there will be required for the next fiscal year, $200,000.

HEADQUARTERS CORPS OF ENGINEERS.

In the labors of the office I have been assisted by the following officers charged with the direction of the four divisions, among which the duties of the bureau of the corps of engineers are distributed:

FIRST DIVISION.—*Fortifications, &c.*, Lieutenant Colonel J. D. Kurtz, brevet colonel United States army.

SECOND DIVISION.—*Battalion and depots, armament, personnel, orders, &c.*, Major T. L. Casey, brevet colonel United States army.

THIRD DIVISION.—*Harbor and river improvements, surveys, instruments*, Lieutenant Colonel J. C. Woodruff, brevet brigadier general United States army; Major J. G. Parke, brevet major general United States army.

FOURTH DIVISION.—*Property accounts, estimates, funds, &c.*, Major W. P. Craighill, brevet lieutenant colonel United States army.

On special duty.—Captain W. R. King, brevet major United States army.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Major General J. M. SCHOFIELD,
Secretary of War.

APPENDIX A.

Extract from the annual report of Brevet Colonel J. B. Wheeler, corps of engineers, upon the lake-harbor improvements in his charge, for the fiscal year ending June 30, 1868.

* * * * * * *

I would respectfully refer to the importance of consistent and uniform action in appropriating money to carry on the improvements recommended for these harbors.

The plan of voting a part of the money asked for to carry out a given improvement, and then neglect it on the succeeding year, when oftentimes most necessary, is bad, vicious, and expensive. The result of such action at a harbor where there is enterprise, is an attempt to continue the improvement by the residents; where there is no feeling of this kind, the work is suffered to remain in the unfinished state. The tendency of the first course is to give a composite order of construction, always unseemly in appearance, and often injurious to the harbor; of the latter course, to destroy and let go to waste what has been done.

Congress has adjourned without appropriating the amounts asked for to continue the works under my direction. This failure will be injurious to many of the harbors, and will increase the future estimates for completion. Fearing such action on the part of Congress, I have carried on the works, so as to secure the greatest possible benefit to the general commerce of the lakes for the money expended, and at the same time have such work conform to the plan approved by the Chief of Engineers.

Hence, where piers already existed, and the plan contemplated a removal of them wholly or in part, nothing was done to these structures, but the money was expended in extending the piers. The cribs being oftentimes placed on the natural bottom of the lake, were allowed to settle well before the pier was built up. By so doing, we were enabled to push out the piers into the lake, and materially benefit many of the harbors. At Ontonagon, Manitowoc, and Aux Becs Scies, where the piers start from the shore, and the cribs were subject to a scour from the current, each crib was settled upon a foundation prepared by a dredging machine. This is the plan adopted for all cribs placed in a depth of water less than 12 feet, and was not departed from, only in those cases where it was extremely difficult to procure dredging machines, or where the cost of building the pier in this manner would have greatly exceeded our estimates. I am, however, of the opinion that in all cases

the advantages should be exceedingly great to compensate us for neglecting to prepare the proper foundation by dredging.

My views have not changed concerning the superior advantages of the pier composed of cribs, with grillage bottoms, and filled with stone ballast. The spaces in the grillage bottoms should be large enough to allow the stone filling to pass through *freely* and settle on the bottom. Where the stone is expensive, as on the east shore of Lake Michigan, or the crib rests upon a quicksand or other yielding foundation, it adds to the expense materially by increasing the quantity of stone filling used. The firm foundation and solid work gained, however, justify the expense.

The proper form of the crib, the dimension of the timbers, the size and number of bolts used, the method of framing or carpentry, are questions that I would like to see discussed, and some uniform plan adopted. If it were possible to relieve the superintending engineer, who disburses the money belonging to as many different appropriations as has been my lot, from a portion of the duties now intrusted to him, it would enable him to devote a part of his time now devoted to paper work, to other and more important professional duties; and as it is impossible, over such an extent of country and so many works, to have an exact personal knowledge of all the details, he trusts to his assistants for the knowledge of the accounts that he has to certify to as correct and just. If these accounts could be certified to by the assistants, and each assistant be responsible for and render accounts for the property bought, it would not increase the number of papers in the engineer department, it would increase the responsibility of each assistant, and would relieve the superintending engineer from a great deal of harassing and annoying paper work.

A No. 1

Harbor of Superior City.

ONTONAGON, MICHIGAN,
July 1, 1868.

COLONEL: I have the honor to submit my annual report on the improvement of the harbor of Superior City, Lake Superior, for the year ending June 30, 1868, in compliance with your letter of instructions of June 20, 1868.

Congress has made an appropriation of $63,000 for the work. The superintendence and inspection was assigned to me June 26, 1867.

This harbor is situated at the western extremity of Lake Superior, in the Bay of Superior, which is about six miles in length and one mile in width, and is separated from the head of the lake by a long narrow sand-spit extending from the bluffs of the Minnesota shore in a direct line to the entry of the harbor, nearly six miles. This renders the Bay of Superior a safe harbor in all winds. The channel of the St. Louis river runs diagonally, and nearly in a straight line across the bay from the mouth of the Bay of St. Louis to the harbor entry, which is the proper mouth of the St. Louis river. This channel has a width of about 300 feet, and a depth from 14 to 30 feet. In all other parts the bay is shoal, and will require dredging to make it available for navigation by vessels drawing more than eight feet of water. The general features of the harbor may be seen by reference to the published lake survey chart.

y to this place.
f them, the Mississippi and Lake Superior, is now being con-
. from St. Paul, Minnesota, The distance to Buffalo by lake is
arly the same as from Chicago. The annual periods of naviga-
about the same. The distance to the waters of the Pacific
ill be about 200 miles less than from Chicago. It seems proper
that the benefits of this improvement to commerce and naviga-
general and national.
ocation of the improvement which has been adopted is at the
entry or outlet of the bay of Superior, which divides Minnesota
om Wisconsin Point, being the State line. The plan is to place
nuous pile of loose rock along the shore of the bay across the
ater to the extreme end of Minnesota Point, and there begin
f cribs in a direction nearly east 192 feet, then curving northward
lius of about 1,200 feet for a distance of about 1,000 feet. Then
ng the pier north 56° east, across the pier, cut channel to 18 feet
f water in the lake. This will gradually narrow the outlet from
to 300 or 350 feet in width at the end of the curve, where it will
ined to the same width by the Wisconsin pier, extending in a
t line from Wisconsin Point to eighteen feet depth of water in the

original plan was to reduce the opening to 300 feet. I would
end that it be made 350 feet, and have so represented it on the
In time of freshets the current often has a velocity of about
es per hour, which will be sufficiently increased when the opening
ed to 350 feet. The total length required to take the Minnesota
18 feet of water is 2,240 feet; and 1,664 feet for the Wisconsin

work was let June 20, 1867. The parties to whom it was assigned
roceeded with the work, excepting the timber, framing, and dredg-
This part of the work was consequently assigned to the next lowest
sible bidders, Messrs. Coburn & Ray, of Superior City, and their
t was executed July 25, 1867.
delivery of the stone was commenced July 22, 1867. The first
was delivered October 8, and the first crib placed in the pier

work and materials was required or expected during the season of 186
The full amount required was accomplished.

The following is the account of materials received and work don during the season of 1867 to November 25:

10,302 lineal feet 12″ × 12″ timber, at 24 cents	$2,472 4
5,162 lineal feet framing, at 20 cents	1,032 0
625¼ cords stone, delivered, at $11	6,877 7
39,538 pounds iron bolts and 400 pounds spikes, at 5 cents	1,996 9
Total	12,379 1

During my absence the work was in the care of Mr. E. C. Clark a foreman till the close of the season.

During the winter the contractors were engaged in cutting and pre paring the logs and timber for the work. The ice left the bay of Superio April 25, 1868. Owing to constantly prevailing northeasterly winds, th broken ice from other parts was driven to the west end of the lake, an remained to the extent of several miles from the harbor entry until th second week in June. It was not so compact as to prevent the passag of propellers, but was a barrier to side-wheel steamers and sail vessels This is the third instance of the kind within the last 12 years. Ordi narily this part of the lake is clear of ice by the last of April or the firs part of May.

The first crib of this season, being the seventh in number, was place on the 25th of April. Seven cribs were placed during May, and ten i the month of June, making to June 30, 1868, 24 cribs, each 32 feet long giving 768 feet length of pier. The superstructure is finished over mor than half the length. The first cribs are in about four feet depth of water which gradually increases till a depth of eight and one-half feet is attained at the 24th crib.

No danger of washing and undermining was apprehended, as the forc of the current along the curve of the pier must be on the opposite sid of the channel. It was considered unnecessary to excavate the foundatio to the usual depth, and as the pier has progressed the theory is proved correct by the accretion of sand on both sides of the pier throughou nearly its entire length. It is now approaching a point where a depth of 12 feet or more should be required. The timber is of an excellen quality of pine, and the work is well done, and does great credit to the contractors, and our foreman, Captain I. B. Schrom, who has given it his constant attention since his arrival on April 18, 1868.

The following is the account of materials received and work done during the year ending June 30, 1868:

37,272 lineal feet 12″ × 12″ timber, delivered, at 24 cents	$8,945 28
8,400 lineal feet piles, delivered, at 13 cents	1,092 00
4,734 feet, board measure, 3″ × 12″ plank for walk, at $16	75 74
41,988 pounds iron bolts, at 5 cents	2,099 40
400 pounds iron spikes, at 5 cents	20 00
905 cords stone for filling, at $11	9,955 00
52 cords brush and slabs for filling, at $3	156 00
31,738 lineal feet of framing done, at 20 cents	6,347 60
Total	28,691 02

Total length of pier in place, 768 feet.

This is now the most favorable season of the year for constructing such work. We shall have at least 36 cribs in place by August 1, 1868.

sent appropriation of $63,000 will be exhausted before the close
esent season. The whole work can be completed during the
f 1869 and 1870.
litional appropriations required will amount to $200,000. One
housand dollars can be profitably expended during the year
ne 30, 1869, which would require an additional appropriation
$70,000.
ber can only be procured to advantage during the winter season,
tial that the appropriation, to be expended profitably each
ould be obtained as early as December of the previous year.
posits of the St. Louis and Nemudjii rivers are large, and it is
that in the course of a few years a bar will be formed at the
piers so as to require their extension. I would estimate that
sion would be required at the end of eight years from their com-
t a cost of $40,000.
imate of the whole cost of work is considerably less than that
t annual report. More length of pier was then estimated, which
tual survey since been found unnecessary, and a greater depth
estimated. The estimate for dredging is also diminished, as it
d that the river current will do a portion of the work.
imates are based on the present contract prices, which are suffi-
gh. Superior City is in the collection district of Mackinac. It
of entry. No customs duties were collected during the year
ne 30, 1868. The amount of fees collected during the year on
nd clearances was $96 14. There were 17 arrivals of steam vessels
sail vessels, total 28; and the same number of departures. The
mounted to 35,730 pounds, being mostly for subsistence.
ncipal shipments were 1,214,000 feet of lumber, 701 shingles, 629
els fish, 6,280 pounds furs.
is a light-house at the entrance of the harbor on Minnesota
latitude 46° 46′ 30″ and longitude 92° 3′ 28″.
ht is fixed, of the fifth order of lens, and can be seen from a dis-
15 miles in clear weather.
it herewith the abstract of contracts, showing the names of
rs and prices; and the estimate of the cost of the whole im-
nt, with the sketch of the harbor entry.
ry respectfully, your obedient servant,

HENRY BACON, *Assistant.*

and Brevet Colonel J. B. WHEELER,
Corps of Engineers United States Army.

Abstract of contracts at Superior City, Lake Superior.

tractors.	Residence.	First class timber.			Second class iron.		Third class filling.		Fourth class framing, per lineal foot.	Fifth class dredging, per cubic yard.
		Pine, lineal feet.	Plank board mess.	Piles, lineal feet.	Bolts, pounds.	Spikes, pounds.	Stone, per cord.	Brush and slabs, per cord.		
		Cts.	*Dolls.*	*Cts.*	*Cts.*	*Cts.*	*Dolls.*	*Dolls.*	*Cts.*	*Cts.*
.....	Superior, Wis...	24	16	13	.....	.....	.....	.....	20	48
.....	Manitowoc, Wis.	.....	.....	.....	.....	.....	11	3	.....	.....
.....	Marquette, Mich.	.....	.....	.....	5	5	.....	.....	.....	.....

Estimate of the cost of one crib 32 feet long, 20 feet wide, and 16 feet high.

32 pieces timber in sidewalks, 12 × 12 inches—32 feet	1,024 lineal feet.		
53 pieces timber, ends, ties, and grillage, 12 × 12 inches—20 feet	1,060 lineal feet.		
5 pieces grillage, 28 feet	140 lineal feet.		
Total	2,224 lin. feet, at 24 cents	$533	76
288 feet board measure 3 × 12-inch plank for walk, at $16		4	61
Framing, including placing, &c., 2,296 feet, at 20 cents		459	20
57½ cords stone for filling, at $11		632	50
6 cords of brush or slabs for filling, at $3		18	00
3,028 pounds iron bolts and 6 pounds spikes—3,034 pounds, at 5 cents		157	70
Total		1,799	77

Estimate of total cost of improvement at Superior City.

122 cribs, averaging 16 feet high, at $1,799 77	$219,571	94
500 cords stone in continuous pile, at $11	5,500	00
8,400 lineal feet of piles for snubbing, ports, fenders, &c., at 13 cents	1,092	00
Driving 300 piles, at $4 each	1,200	00
Dredging 25,000 cubic yards, at 48 cents	12,000	00
Add 10 per cent. for contingencies	23,936	39
Total	263,300	33

A 2.

HARBOR ONTONAGON, MICHIGAN.

ONTONAGON, MICHIGAN, *July* 1, 1868.

COLONEL: In obedience to your letter of instructions of June 20, 1868, I present my annual report of the progress and condition of the improvement of the harbor of Ontonagon, Lake Superior, during the year ending June 30, 1868, embracing an account of the plan adopted, estimate of the amount required for its completion, and the amount that can be profitably expended during the year ending June 30, 1869, and the general and local advantages of the improvement to commerce.

This work was assigned to my charge June 26, 1867. The harbor of Ontonagon is situated at the mouth of the Ontonagon river, on the south shore of Lake Superior, about midway between the natural harbors of the Apostle islands on the west, and Copper Harbor, at Keweenaw Point, on the east, distant from La Point about 75 miles, and from Copper Harbor 85 miles, with no intervening harbor excepting Eagle Harbor, which is 14 miles from Copper Harbor. Ontonagon is the most favorably situated, and is the best if not the only point on this shore of 150 miles, that can by artificial means be rendered a safe harbor of refuge. It is the commercial centre of the best argricultural region of Lake Superior, and one of the best mining sections; both being but very partially developed. It is very important to the interests of commerce and navigation, general and local, that the improvement which is begun here should be carried forward to completion.

Ontonagon river is about 400 feet in width, and for about one-half a mile from its mouth has a depth of 8 to 12 feet, and a depth of 5 feet for 4 miles above.

The lake shore is sand. The modern deposits of the river extend nearly half a mile into the lake. There is no channel at present, entirely across this bar, of more than six feet depth of water. Channels have been made by the river current, and closed by the action of the wind

waves. In 1856 vessels drawing from 10 to 11 feet of water could
r the mouth of the river. In 1859 the depth was reduced to 8 feet,
to 6½ feet in 1865. During the greater part of the seasons of 1866
1867 vessels could enter drawing 9 to 10 feet of water. The channel
closed to its present depth by a severe storm during the last days
ctober, 1867. The plan of improvement adopted is to extend two
llel piers of cribs, in a direction nearly northwest, entirely across
ar to 18 feet depth of water, making a pier of cribs on the easterly
of 2,560 feet length, and 2,112 feet on the westerly side; the clear
h between the piers to be 250 feet. I annex a sketch of the mouth
ie river, showing the present condition of the work, and also the
ins of attempted improvements made some years since by the
ty of Ontonagon.
shows the position and progress of our work on the east side of the
; there being 12 cribs placed, 387 feet and 62 feet of connecting
, from the dock to crib No. 1, built on piles sawed off to low-water
ce, to correspond to the crib-work in the superstructure. On the
side it is proposed to begin the pier of cribs at the end of the old
works. From that point to the shore the old work is very imperfect,
there is a space of 25 feet where there are no piles left.
would recommend that the continuous piling be completed on the
, and driven at 20 feet width on the back side, and all sawed off to
water surface, and superstructures built to correspond to the crib
This method of making the connection with the shore is recom-
ded on account of its economy compared with that of removing the
and placing cribs. An estimate is included for this 256 feet in
th, as well as the 62 feet on the other side before mentioned. The
work on the easterly side consists of two rows of continuous piling,
about 300 feet in length, with some detached piles, and the remains
ur sunken cribs in the same line, by that time require some repairs.
uld estimate the amount required for extension and repairs, at the
of 12 years, at $40,000.
ie work was awarded to the different contractors June 20, 1867.
contracts for timber and framing, and stone and brush for filling,
signed July 24, 1867. On account of the lateness of the season
the work was let and contracts signed, but a small amount of work
expected or required during the season of 1867. The contractors
all the material delivered by October 1, 1867, which was required
at time by their contracts.
ie work of framing was begun October 7, 1867, and five crib-bottoms
framed and launched by October 19, 1867.
ter much delay in getting the dredging machine in working order
xcavating the foundation, several ineffectual attempts were made
ace a crib. The work was abandoned for the season November 8,
, the constantly recurring storms not giving time enough to pre-
a foundation and place a crib. At the close of the season of 1867,
mber 30, the following materials had been delivered: 8,289 lineal
of 12 by 12 inch timber; 644 lineal feet of piles; 5,610 cubic yards
one for filling; 40,000 pounds of iron bolts and 400 pounds of spikes.
uring the winter months the contractors were engaged in cutting
making the timber on the Ontonagon river. The work of framing
preparing the foundations for cribs was begun April 27, 1868. The
crib was placed May 2 to nearly eight feet depth of water. Three
were placed during the month of May, in which the weather was
unfavorable, and nine have been placed during June, making 12 in
They were ordered to be sunk to at least nine feet depth of water.

The first four are nearly to eight feet depth; the remainder are to nine feet depth.

No stone for filling nor iron bolts and spikes have been delivered this season. The contractors will begin the delivery of the stone and iron within a few days.

The following is the account of work done and material delivered during the year ending June 30, 1868:

39,305 lineal feet of 12 by 12 inch timber, at 15.7 cents	$6,170	88
844 lineal feet of piles, at 8 cents	67	52
5,610 cubic yards of stone filling, at $3 75	21,037	50
202 cubic yards of slabs for filling, at $1 26½	255	53
40,000 pounds of 1⅛-inch square bolts, at 5 cents	2,000	00
400 pounds of spikes, at 5 cents	20	00
14,897 lineal feet of framing done, at 16.7 cents	2,487	80
Total	32,039	23

The total length of pier in place is 449 feet.

The superstructure is begun, but no portion completed.

This is now the best season of the year for placing the cribs. We shall without doubt have 25 cribs in place by August 1, (865 feet length of pier.) About 40 cribs will be in place and the superstructure finished before the close of the season. It is not probable that more than $20,000 of the appropriation of $97,600 will remain unexpended at the close of the season of 1868. From that time to the close of the fiscal year $80,000 can be profitably expended, thus requiring an appropriation of $60,000 for the year ending June 30, 1869.

I have made daily observations of the water surface of the lake during my presence at Ontonagon, excepting in the frozen season, noting also the force and direction of winds. I give the average elevation of the water, generally from three daily observations, with the greatest variation during the day.

The base is above the water surface, so that when the given figures are least the water is highest. The base is the same as the one used by the lake survey at this place. During a small portion of the time there is but little or no ebb and flow; but during the greater part of the open season there is a constant vibration, or ebb and flow; at very nearly regular periods of time flowing from 7½ to 10 minutes and ebbing in the same time. This vibration, which during one day amounted to 25 inches, is entirely independent of winds, excepting in a few observed instances, like October 29, 1867, when the water was steadily raised by a northerly gale. Ontonagon is situated in the collection district of Mackinac; it is a port of entry. Mr. E. F. Prince, the deputy collector, informs me that the duties on imports collected here amounted to $280 10; the amount collected for fees is $155 05; total collected during the year ending June 30, 1868, $435 15.

The number of vessels arrived during this year is 79 steamers, 59,600 tons; 27 sail vessels, 3,291 tons. Total, 62,891 tons.

Clearances: 79 steamers, 59,600 tons; 28 sail vessels, 3,379 tons. Total, 62,979 tons.

There is a light-house at Ontonagon, of the fifth order of lens, with a fixed light which can be seen in clear weather at a distance of 15 miles. The business of the Lake Superior regions is in a very depressed condition, owing to the low price of copper and the high cost of mining,

caused by the high price of labor and subsistence. There can be no doubt of the great value of this region and a future revival of business. I annex to this report the sketch of the mouth of the river before mentioned, and the following estimate of the full cost of the improvement based on present prices; also an abstract of contracts, with names of contractors and prices, and tables of domestic exports and imports.

Respectfully submitted.

HENRY BACON, *Assistant.*

Brevet Colonel J. B. WHEELER,
Major of Engineers U. S. Army.

Estimate of the cost of one crib 32 feet long, 20 feet wide, 16 feet high.

Thirty-two pieces 12 by 12 inch timber, 32 feet long, 1,024 feet; 53 pieces 12 by 12 inch timber, 20 feet long, 1,060 feet; 5 pieces 12 by 12 inch timber, 28 feet long, 140 feet. Total, 2,224 feet, at 15.7 cents, $349 17.

288 feet board measure plank for foot-walk, at $18 per M...	$5 18
Framing, including placing, &c., 2,296 feet, at 16.1 cents....	383 43
272 cubic yards stone for filling, at $3 75.....	1,020 00
27 cubic yards slab or brush for filling, at $1 26½	34 15
3,028 pounds 1⅛-inch square bolts and 6 pounds of spikes, 3,035 pounds, at 5 cents.....	151 70
Total cost of one crib.....	1,943 63

Estimate of total cost of the improvement.

146 cribs, averaging 16 feet in height, at $1,943 63.....	$283,769 98
15,000 lineal feet of piles for connecting work, &c., at 8 cents.....	1,200 00
Driving 600 piles for connecting work, at $5 each.....	3,000 00
Superstructure of pier of 318 feet length, built on piles, 6,400 lineal feet of 12 by 12 inch timber, at 15.7 cents....	1,004 80
2,862 feet board measure 3-inch plank in foot walk, at $18 per M	51 52
Framing 7,115 feet superstructure, including cutting piles, &c., at 20 cents.....	1,423 00
2,968 cubic yards of stone for filling, at $3 71.....	11,130 00
9,740 pounds 1⅛-inch square bolts and 60 pounds spikes, 9,800 pounds, at 5 cents	490 00

COST OF REMOVING OBSTRUCTIONS.

Removing 455 piles, at $6.....	2,730 00
Removing remains of old cribs.....	1,000 00
Total.....	305,799 30
Add 10 per cent. for superstructure and contingencies....	30,579 93
Total.....	336,379 23

Abstract of contracts at Ontonagon, Lake Superior.

Name of contractors.	Residence.	1st class: Timber.				2d class: Iron.		3d class: Filling.		4th cl's: Fram'g.	5th cl's: Dred'g.
		Pine, per lineal foot.	Other, per lineal foot.	Plank, board measure.	Piles, per lineal foot.	Bolts, per pound.	Spikes, per lb.	Stone, per cubic yard.	Brush or slabs, cubic yards.	Per lineal foot.	Per cubic yard.
		cents.	*cents.*		*cents.*	*cents.*	*cents.*			*cents.*	
Gelley & Weston.	Milwaukee.	15 7-10	15 7-10	$18	8	.....	.....	.....	.....	16 7-10	.....
S. S. Vaughn	Bayfield...	.....	.....	.....	.....	.....	.....	$3 75	$1 26¼	.....	.....
Peter White.....	Marquette .	.....	.....	.....	.....	5	5	.....	.....	.....	.....

Domestic exports from the Port of Ontonagon during the year ending June 30, 1868.

	Tons.
Potash	20
Hay	250
Copper	1,500
Fish, 1,000 half-barrels fish	75
Leather	30
Sundries	50
Lumber, 1,000 feet	250
Total	2,175

Domestic imports.

	Tons.
4,100 barrels flour	451
180 barrels lime	22
120 barrels lard	18
60 barrels molasses	15
100 barrels oil	15
230 barrels pork	35
365 barrels sugar	42
400 barrels salt	60
75 barrels vinegar	11
35 barrels fuze	3
290 barrels hams	41
90 kegs nails	4½
4,000 kegs powder	60
650 boxes candles	19½
3,000 bushels corn	84
13,500 bushels oats	216
170 tons meal	170
1,150 tons sundries	1,150
Total	2,417

A 3.

EAGLE HARBOR.

ONTONAGON, MICHIGAN, *July* 1, 1868.

COLONEL: In obedience to your letter of instructions of June 20, 1868, I submit my annual report of the progress and condition of the improvement of Eagle harbor, Lake Superior. The superintendence and inspection of this work was assigned to me July 20, 1867.

An appropriation of $65,000 has been made by Congress for the improvement.

Eagle Harbor is situated on Keweenaw Point, about 14 miles west of Copper Harbor. It is an indentation of the rocky coast, about seven-eighths of a mile in length east and west, and one-fourth of a mile in width, with an opening into the lake of about 1,500 feet in width. This opening has less than nine feet depth of water excepting on about 200 feet.

The portion of the harbor which has a depth of water of 12 feet or more is directly in front and westerly from the entrance. The eastern portion is shoal. The bottom in the harbor at the entrance and approaches is solid trap rock, covered in many places with smooth pebbles.

At the present stage of the water it is difficult for vessels to enter drawing more than nine feet of water, and only in calm weather.

The present stage of water is about one foot below its average level, the whole general variation being about two feet, leaving out of the account the sudden and temporary fluctuations. In order to obtain a proper entrance to the harbor it is necessary to remove the rock to the depth of 14 feet of water. This would enable vessels drawing 11 feet of water to enter at all times, unless in a very heavy sea.

The published chart of this harbor (lake survey) will show its general features. I submit herewith a sketch marked A, showing the harbor entrance and the position of the proposed channel, and soundings taken in and adjacent to the same. Also a table of soundings in squares of 10 feet, marked B. I made the survey and soundings during January and February, 1868. The work was done on the ice with care and precision.

The plan of improvement adopted is to excavate a channel across the bar at the entrance to 14 feet depth below the water surface of February, 1868, and to a width of 80 feet—the average length being about 280 feet—and construct a breakwater of cribs 20 feet in width, closing the opening of 1,500 feet, excepting 220 feet, thus leaving space for the further widening of the channel. The water-level from which the soundings were made is preserved by three bench marks, the position and elevation of which are described and given on the sheet containing the soundings and the sketch before mentioned. I have made calculations of the excavations required to obtain 14 feet of water, and also 13 feet, in sections of 10 feet in width, parallel to the target range, numbering from east to west; section No. 1 being 55 and 65 feet east of the target range.

The following are the results:

Excavation to 14 feet depth.				Excavation to 13 feet depth.			
Sec'n.	Cubic feet.	Sec'n.	Cubic feet.	Sec'n.	Cubic feet.	Sec'n.	Cubic feet.
1	8,415	12	6,800	1	5,265	12	4,280
2	8,095	13	6,935	2	4,985	13	4,480
3	8,225	14	6,945	3	5,185	14	4,560
4	7,980	15	6,835	4	5,090	15	4,590
5	7,430	16	6,775	5	4,630	16	4,585
6	7,370	17	6,935	6	4,565	17	4,765
7	7,620	18	7,065	7	4,730	18	4,930
8	7,680	19	6,865	8	4,755	19	4,735
9	7,310	20	7,055	9	4,435	20	5,035
10	7,010	21	7,960	10	4,215	21	5,540
11	6,840	22	9,010	11	4,170	22	6,580

The original plan was to excavate to a width of 130 feet. This should at some future day be carried out.

The location of the channel adopted is from sections 10 to 17, inclusive, 80 feet in width.

It will appear from the above table that this will require 2,039 $\frac{81}{100}$ cubic yards of excavation for the 14 feet depth.

This location requires the least excavation to bring 80 feet in width to the required base.

The least excavation required for 130 feet in width to the same base, is found to be from sections No. 8 to No. 20, inclusive, making 3,372 $\frac{22}{100}$ cubic yards. The least excavations for 130 feet in width to the depth of 13 feet is found from sections No. 5 to No. 17, inclusive, 2,176 $\frac{30}{100}$ cubic yards.

The only part of the work let is the removal of the rock.

Proposals were received and opened according to advertisement, July 31, 1867.

The following is the abstract of the bids received:

No.	Names of bidders.	Residence.	Price per cubic yard.	Remarks.
1	John A. Baily.....	Detroit, Michigan.....	$75 00	
2	James H. Mallaroy....	Chicago, Illinois.....	59 40	
3	David Smoke.....	Manitowoc, Wisconsin.	54 00	Rejected for informality.
4	David Quinn	Chicago, Illinois.....	58 00	
5	Packhard & Hoes.....	Manitowoc, Wisconsin.	63 87	

The contract was assigned to David Quinn as the lowest responsible bidder, at $58 per cubic yard. It was executed August 10, 1867. Mr. Quinn visited Eagle harbor during the last days of August and first of September, 1867, but as the weather proved very unfavorable, no work was done excepting some experiments of exploding powder on the surface of the rock beneath the water, which were unsatisfactory. Mr. Quinn visited Eagle harbor again about the 26th of October, and remained but a few days, as the weather was constantly boisterous. Nothing could then be done till the harbor should be frozen over in winter. This does not often happen, excepting very temporarily, sooner than the middle of January.

In 1868 it was frozen about January 24, and after breaking and moving out several times, it was broken up for the season, March 10, 1868. I completed my survey and soundings of the harbor entrance February 9, and Mr. Quinn began the work of drilling directly after, having previously made some unsatisfactory experiments in surface-blasting. There is not a sufficient depth of water for this method. When the ice broke up for the season, March 10, 1868, the work of drilling, grappling, &c., was well organized, there being about 40 men employed. One hundred cubic yards of rock had been removed.

The harbor entrance is usually well frozen for more than two months during the winter and spring, and often more than three months.

The work was suspended till Mr. Quinn arrived, May 27, 1868, when he again resumed the work of drilling and grappling the loose rock. Experiments on this work have proved that nitro-glycerine is the best explosive material that can be obtained, and Mr. Quinn contracted for the delivery of 1,000 pounds, or more, by the last of May.

For some reason, said to be on account of quarrels between the manufacturers, none has been received, and I fear that there will be a further delay of a month or more. This delay is very unfortunate, as we are losing the best of the season, which is a very favorable one. A large number of holes have been drilled to at least six inches below the grade line, so that short work may be made of removing the rock when the blasting oil is obtained. A pound of nitro-glycerine in a 2½-inch hole breaks the rock into small fragments for several feet distance, breaking it much smaller below than at the surface of the rock. It is easily drilled and fractured, being intersected by close seams. The drilling is done on rafts, by the use of spring-poles so placed as to use the drills near the centre of the raft, where there is but little motion to the raft in a moderate sea. It has proceeded during the present season with but very little interruption by storms.

Mr. Quinn has four scows and a large amount of grappling machinery. He has also a dredging machine of a simple kind, worked by a small steam-engine.

The method of drilling is perhaps primitive, but not very expensive, costing not more than $2 per lineal foot for 2½-inch holes. If the work of constructing the breakwater were in progress, the rock removed from the channel could be completed during the season of 1869.

I would recommend that the work of constructing the breakwater be let as soon as the appropriation is made for the whole work.

I have to report only 100 cubic yards of rock excavation to July 1, 1868. The whole work can be completed during this season and that of 1869.

One hundred thousand dollars can be profitably expended during the year ending June 30, 1869.

Responsible parties would now contract to do the rock excavation at $40 per cubic yard.

Eagle harbor is in the collection district of Mackinac. It is a port of entry. I learn from Mr. P. C. Bird, the deputy collector of customs, and keeper of the light-house, that there were no custom duties collected on importations, and that the fees for reports and clearances amounted to $79 05 during the year ending June 30, 1868, and that the light at Eagle harbor is of the fifth order, revolving F. *b.* F.

The benefits of this improvement to commerce and navigation are mostly local.

The copper mining region, which is tributary to this place, is one of the richest on Lake Superior. The present is a time of great depression in copper mining, owing to the low price of copper and high cost of subsistence.

The annexed tables of receipts and shipments are some indicators of its importance. When this improvement is finished it will need no repairs, excepting on the superstructure, by reason of the natural decay of the timber in the breakwater.

I submit herewith the following estimate of the whole cost of the improvement, the sketch of the entrance to the harbor, the table of soundings, and table of receipts and shipments.

Very respectfully, your obedient servant,

HENRY BACON, *Assistant.*

Major and Brevet Colonel J. B. WHEELER,
Corps of Engineers U. S. A.

Estimate of the cost of improving Eagle harbor, Lake Superior.

Cost of one crib for breakwater, 32′×20′×12′. (Average:)	
24 pieces of timber, 12″×12″×32′=768 lineal feet, for sidewalk; 41 pieces of timber, 12″×12″×20′=820 lineal feet, for grillage ties and ends; 5 pieces of timber, 12″×12″×28′=140 lineal feet, for grillage. Total, 1,728 lineal feet, at 20 cents	$345 60
288 feet B. M. 3″×12″ plank for walk, at $20 per thousand.	5 76
2,806 pounds iron bolts, 1⅛-inch square, at 5 cents	140 30
6 pounds spikes, at 7 cents	42
210 cubic yards stone for ballast, at $1 75	367 50
18 cubic yards slabs or brush, at 80 cents	14 40
Framing, including sinking, and placing cribs, 1,752 lineal feet, at 20 cents	350 40
Total cost of one crib	1,224 38
40 cribs, making 1,280 feet of pier, at $1,224 38	$48,975 20
2,040 cubic yards rock excavated, at $58	118,320 00
Total	167,295 20
Add 10 per cent. for contingencies	16,729 52
Total cost of 80 feet width of channel and breakwater	184,024 72
Additional cost of excavating rock to 130 feet width of channel, 1,332 $\frac{41}{100}$ cubic yards, at $40	53,296 40
Total	237,321 12

UNITED STATES ENGINEER'S OFFICE,
Milwaukee, Wisconsin, February 21, 1868.

GENERAL: I mentioned in my report of monthly operations for January, 1868, dated February 13, that I had required Assistant Henry Bacon to take advantage of the ice, if it formed over the entrance of Eagle harbor, and remeasure the amount of excavation required in the channel at this harbor. He has completed the work, and I attach herewith his report and computations. These latter have been carefully examined in this office, and found to be an excess of the true amount,

21.34 cubic yards, an excess arising from averaging the depths, and calculating each column instead of computing the cubic contents of each square by itself. I attach a copy of the tracing furnished me by General Reynolds, and is a copy, I suppose, of sketch A, referred to in his report of October 13, 1866. Mr. Bacon finds a difference in the position of the channel, in the general depth of the water, and in the coutour of the surface of the rock. Locating the target range by buoys in 1865 may explain the first; the surface of the lake being lower now than then, explains the second; and the soundings made at irregular distances, affected by the undulations of the water, and these approximated for those points not ascertained, would explain the third difference. The peculiar advantage afforded by the ice, and the soundings made every 10 feet, render Mr. Bacon's measurements more accurate and his computations more reliable. We see, then, that to improve this harbor, as contemplated, we must remove about 3,600 cubic yards of rock. It seems a waste of money to continue the work if Congress should fail to appropriate an additional sum. Mr. Bacon incurred the expense of $97 50 for payment of laborers to assist him. I have sent him pay-rolls to have signed, and would respectfully ask for authority to pay the amount incurred in this remeasurement.

I am, general, very respectfully, your obedient servant,

J. B. WHEELER,
Major of Engineers and Brevet Colonel U. S. A.

Major General A. A. HUMPHREYS,
Chief of Engineers, Commanding Corps of Engineers U. S. A.

EAGLE HARBOR, *February* 8, 1868.

SIR: Enclosed I transmit the result of my surveys and soundings of Eagle harbor, made for the purpose of locating the channel and measuring the rock excavation to be done. I also enclose the voucher of Mr. Quinn for the labor furnished, which covers the whole expense aside from my own services, $97 50. I have made the survey and soundings with care and precision. I find that the plan or sketch which was furnished from your headquarters is not correct horizontally, to say nothing of the soundings. The west side of the channel, as I have laid it for 13 feet of water, 105 feet from the target range, is further (northeasterly) from the dock than the represented distance on the sketch from the dock to the west side of the channel, (65 feet from range.) You will see by the results of the calculation that the least work is required on the 14-foot base by locating the channel five feet, and 135 feet west of the target range, while on the base a foot higher the lines are 25 feet east and 105 feet west. As Mr. Quinn's contract requires him to cut 14 feet below low water, I have directed him to aim for that depth until he hear from you, but to work only on the 80 feet in width from sections No. 10 to 17 inclusive, 25 to 105 west of range. I have also instructed him to do no work on rock already 13 feet below till your decision is made. The water must have been at least one foot higher than at present when the soundings were made in 1865. I suppose it is out of the question to cut 130 feet width and 14 feet below the present level. We must either raise the base or lessen the width. If there is never less than 13 feet depth it would be enough for any vessels which can pass the Sault canal, even allowing something for undulating in rough weather, which will be to some extent remedied by the breakwater. It would be well if you would

write the decision to Mr. Quinn at Eagle harbor as well as to me, especially if the base is raised, as his instructions are to cut 14 feet.

I expect to return to Ontonagon next week, starting 10th. I have preserved range lines on shore so as to be able to identify the various points in the channel.

Mr. Quinn has tried another surface blast with powder since my monthly report, but without perceptible effect. He is preparing now for drilling extensively. You will notice in the calculation of excavation that when the cuttings run from above to below base on the 10-foot sections, they are estimated as zero. At the point below this is slightly erroneous, and will be corrected on final estimate. The calculations otherwise are mathematically correct. The work is laid off in 10-foot squares.

* * * * * * *

Very respectfully, your obedient servant,

HENRY BACON.

Colonel J. B. WHEELER,
Major of Engineers U. S. A., Milwaukee, Wisconsin.

A 4.

OFFICE UNITED STATES ENGINEERS,
Milwaukee, June 30, 1868.

SIR: I have the honor to submit the following report upon the harbor of Marquette, Michigan:

This harbor is situated upon the south shore of Lake Superior, at a distance of about 160 miles to the westward of the Sault St. Marie, which is at the head of what is termed the St. Mary's river, and about 125 miles west by south of Whitefish Point, which is the eastern extremity of Lake Superior proper. The harbor on the south side of Grand island is the only place which offers shelter to vessels between these two points; and as the natural harbor of Marquette is exposed to the heavy seas from the northeast, it has heretofore been impracticable for vessels to receive or discharge freight, or even to ride at anchor during the prevalence of a moderate gale of wind from that quarter. Under such circumstances they have been obliged to run back to Grand island, a distance of about 35 miles, or to beat about upon the lake until the wind has subsided. The distance from the harbor of Marquette to the nearest safe anchorage in Keweenaw bay is about 70 miles to the west. It will therefore be seen that for a distance of 195 miles of stormy coast line there has heretofore been but one place at which vessels could obtain shelter from a northeast storm; so that, independent of the benefit to be derived by the local interest of Marquette, the worth of improvements now being effected at this point will be of the first importance to the general commerce of the lake. It is unnecessary for me to dilate upon the important interests which are being developed continually in the districts which are dependent upon this harbor for the shipment of minerals and the receipt of supplies.

Appreciating the necessity of improving this harbor, Brevet Major W. F. Reynolds, corps of engineers, was instructed by the chief of engineer department to examine the harbor and make an estimate of the cost of improving it, and forward the same to the bureau at Washington, which he did in October, 1866. The plan he proposed was adopted

by constructing a breakwater to the heavy seas from the northeast, of 2,000 feet in length.

His estimate of the cost of such improvement when completed was $385,129 58. In 1867 the Congress of the United States appropriated $85,000 towards the carrying out of this project, and the construction of the breakwater was commenced under your direction in the month of August, 1867, since which time the work has been carefully prosecuted with a view to securing its stability and permanency. Five cribs were sunk during the fall, each of 32 by 20 feet, and were filled with stone to the water surface. These were allowed to remain through the winter without additional superstructure, for the purpose of ascertaining the effect which would be produced upon them by the winter storms. In March, 1868, it was found that the water alongside the cribs, in places where it had been previous to their being placed at the respective depths of 9, 10, and 11 feet, had changed to the relative depths of 13, 14, and 16 feet on the side exposed to the sea; and also on the inner or shore side a similar effect had been produced, but not to such an extent as on the outer side. This change must have been effected by the combined forces of a lateral current from the shore, and the undertow subsequent to the impact of the wave with the crib, as at a distance of 50 feet from the pier no change in the depth of the water was perceptible. This destructive effect was checked by distributing stone along the side of the pier, and I have no serious apprehensions in regard to the permanency of the work hereafter, if it is shielded by an apron of stone to the seaward. On the 14th day of March a sixth crib 50 by 25 feet was sunk through the ice, and the superstructure has been built upon the six cribs, forming a finished length of crib-work of 210 feet, which, in connection with 100 feet of loose stone pier-work built from the shore to the inner crib, forms a total length of finished pier of 310 feet.

Messrs. Gelley & Weston, who were the original contractors for framing the cribs, failing to fulfil the conditions of their contract, left the work, which was afterwards awarded to Mr. William Ferguson, the next lowest responsible bidder; and had it not been for the disastrous conflagration which destroyed the entire business portion of the town the prosecution of the work would have been energetically carried on.

None of the government property was destroyed, although the warehouse upon one of the docks was burnt, in which a quantity of iron bolts belonging to the government were stored. Unfortunately the public papers relative to exports and imports, &c., were lost, so that no reliable information can be obtained in regard to them.

Mr. Ferguson is now prepared to conduct the work vigorously, and it is expected that two more cribs, 50 feet by 25 feet, which will complete the second section of crib-work, and six cribs, each 50 feet by 30 feet, forming the third section, will be placed out this season, making a total length of pier of 710 feet.

Captain R. S. Littlefield has been acting as foreman at this harbor since the closing up of the work in Green Bay last fall. The fidelity with which he has discharged the duty required of him is deserving of the highest commendation.

By your orders I made a plan of crib 50 by 30 by 27 feet for Marquette harbor; also a model of the same for use of contractor, the bill of materials required for which is as follows:

Number of courses from bottom.	12-inch square timber. Length in feet. 20s.	30s.	23s.	27s.	46s.	Am't in lineal feet.	1¼-inch square iron bolts. Lengths. 20-in.	32-in.	Weight in pounds.	Stone. Cubic yards.
1	2	4	.....	.....	1	206	.....	.....	.....	44.00
2	2	15	.....	.....	1	536	32	.....	228.16	32.59
3	.....	5	2	2	7	572	70	33	875.30	31.11
4	.....	5	2	2	1	296	.....	37	421.80	40.88
5	2	7	.....	.....	1	296	3	37	443.19	40.88
6	2	7	.....	.....	1	296	.....	39	444.60	40.88
7	.....	5	2	2	1	296	.....	37	421.80	40.88
8	.....	5	2	2	1	296	.....	40	456.00	40.88
9	2	7	.....	.....	1	296	.....	39	444.60	40.88
10	2	7	.....	.....	1	296	.....	37	421.80	40.88
11	.....	5	2	2	1	296	.....	40	456.00	40.88
12	.....	5	2	2	1	296	.....	39	444.60	40.88
13	2	7	.....	.....	1	296	.....	37	421.80	40.88
14	2	7	.....	.....	1	296	.....	40	456.00	40.88
15	.....	5	2	2	1	296	.....	39	444.60	40.88
16	.....	5	2	2	1	296	.....	37	421.80	40.88
17	2	7	.....	.....	1	296	.....	40	456.00	40.88
18	2	7	.....	.....	1	296	.....	39	444.60	40.88
19	.....	5	2	2	1	296	.....	37	421.80	40.88
20	.....	5	2	2	1	296	.....	40	456.00	40.88
21	2	7	.....	.....	1	296	.....	39	444.60	44.88
22	2	7	.....	.....	2	342	.....	27	307.80	39.26
23	.....	5	2	2	1	296	10	34	458.90	40.88
24	.....	5	2	2	1	296	.....	31	353.40	40.88
25	2	7	.....	.....	1	296	10	27	379.10	40.88
26	2	7	.....	.....	1	296	.....	34	387.60	40.88
27	.....	7	2	2	1	356	26	31	538.78	.....
Total	28	170	26	26	94	8,524	151	910	11,450.63	1,046.32

108 cubic yards of brush, slabs, or stone to be placed in the intervals between cribs.

450 feet (board measure) of 3-inch plank for foot walk.

9 pounds of 6-inch spikes.

Cost of crib, 50 by 30 by 27 feet, at the contract prices for materials and labor at Marquette:

8,524 lineal feet of timber, 12 inches square, at 14⅓ cents per lineal foot	$1,221 77
11,451 pounds of wrought-iron bolts, at 4⅞ cents per pound	558 23
1,154 cubic yards of stone ballast, at $1 25 per yard	1,442 50
8,524 lineal feet of framing, at 12 cents per foot	1,022 88
450 feet (board measure) of 3-inch plank for foot walk, at $16 per thousand	7 20
9 pounds of spikes	44
	4,253 02
Add 10 per cent. for contingencies	425 30
Total cost of one crib	4,678 32
	6
Total cost of six cribs forming 3d section of crib-work	28,069 92

Fifty thousand dollars can be profitably expended at this harbor during the next fiscal year. The work will be of a permanent character, requiring no further outlay after its completion than such as is incidental to the natural decay of the timber forming the superstructure, which is of the best quality of white pine.

Total iron ore and pig iron in 1867	500,231

enue collected in 1867, $9,000.

quette is situated in the collection district of Mackinac. It is a f entry. The nearest light-house is situated on Light-house Point, mile northwest of the business part of the town.

ave the honor to remain, very respectfully, your obedient servant,

W. H. HEARDING,
Assistant Engineer.

vet Colonel J. B. WHEELER,
Major Corps of Engineers U. S. Army.

Abstract of contracts for improving Marquette harbor, Michigan.

Contractors.	Nature of contracts.	Price.
lliam Ferguson	12-inch square pine timber, per lineal foot	$00 14½
illiam Ferguson	Stone, per cubic yard	1 25
illiam Ferguson	Brush, per cubic yard	1 25
illiam Ferguson	Plank, per M, board measure	16 00
illiam Ferguson	Framing, per lineal foot	12
ter White	Iron bolts, per pound	4⅞
ter White	6-inch wrought iron spikes, per pound	4⅞

Abstract of materials received, labor performed, and total amount paid from July 1, 1867, to June 30, 1868.

Timber.	Iron.		Ballast.		Framing.	Cribs sunk.	Amount paid.
	Bolts.	Spikes.	Stone.	Brush.			
Lineal f...	..						

A 5.

OFFICE UNITED STATES ENGINEERS,
Milwaukee, January 30, 1868.

SIR: In obedience to your orders of June 20, 1868, I respectfully submit the subjoined report upon the harbor at Green Bay city, Wisconsin:

At an early period the importance of this harbor as a governing point in the commercial interests of the northwest was well known and appreciated by the leading business men of the country. For many years the North American Fur Company carried on a lucrative trade with the Indians at the post which they established on the east side of the Fox river, at a distance of one and one-fourth mile from its mouth, and where the city of Green Bay now stands.

At a later period the United States government established a military post on the west side of the river, around the remains of which the town of Fort Howard has since been built. Covering the débouche of the river, and at a right angle with its inland course, a deposit of sand has been formed in the bay at a distance of one and a half mile, which has diverted the current to the eastward and formed a tortuous channel difficult to navigate in the daytime, and which it is almost impracticable to follow in the night. The plan which has been adopted for the improvement of the approach to this harbor is the cutting of a direct channel from the mouth of the river, across the bank, and extending to the deep water of the bay outside.

Two or three estimates have been made of the cost of this improvement, and finishing it with a revetment of either close-piling or crib-work, which have differed in accordance with the views of the officers who have reported upon it.

The length of the section of the channel requiring protection at its sides, and the character of the required, protection, was a problem difficult to solve, except by practical experiment. The work of dredging was commenced in the autumn of 1866; but, owing to the incapacity of the dredge, but little was accomplished.

In the spring of 1867 new machinery was applied, and at the close of the season a channel of nine and one-half feet in depth had been cut, from the old channel southwest of Grassy island, through the island, and to the line of seven and three-fourths feet of water in the bay.

After the dredge was laid up for the winter, soundings were taken in the cut on cross-sections 25 feet apart for its entire length, and a plat of the same was forwarded to this office by Captain R. S. Littlefield, who was foreman at the harbor during the working season. The channel banks remained unprotected during the winter, and before dredging was resumed this spring similar soundings were taken and a plat made, for the purpose of ascertaining by comparison the effect produced during the winter by the action of the current from the river on the one side, and the counter-current from the bay on the other, which is produced by the rise of water from northeast winds. So long as the water was covered with ice, the ebb and flow of these currents were the only destructive forces acting upon the channel banks; the change effected was found to be so slight that it was considered expedient to continue the excavation by dredging.

Soon after the ice disappeared a portion of the channel bank northeast of the island was removed by the seas from a succession of northeast storms, and a portion of the sand deposited across the channel, which occupied the dredge for two or three days to remove.

The oldest inhabitant does not remember a season when the wind has prevailed so long from that quarter; but as there is a possibility of similar storms recurring, it would seem to be advisable to secure the work which is already done by protecting the banks of the channel through and in proximity to the island. At the present time the cut is about 125 feet wide at its southern extremity, carrying the same width to a distance of 100 feet north of island. Beyond this for a distance of 280 feet it is about 100 feet wide. Another section extends for a stretch of 200 feet, which is 65 feet in width, and a single cut of 35 feet in width extends from this to the natural depth of nine and one-half feet of water in the bay, so that steamers drawing no more than that depth of water find no difficulty in passing through the straight cut by keeping on the west side, which is so far the finished or straight side of the channel. One hundred and seven thousand eight hundred and thirty-one cubic yards of earth have been taken from the cut and dumped at a distance of three-fourths of a mile from the channel, between dates July 1, 1867, and June 30, 1868.

The contractor for dredging at this harbor is General W. S. Smith. The price paid for dredging is 50 cents per cubic yard. The cost of close-piling 1,000 feet of channel on either side (adopting Lieutenant J. B. Quin's estimate of last year for the proportionate length of channel) would be about $37,000. Sixty-five thousand dollars could therefore be profitably expended at this harbor during the next fiscal year in dredging the channel and constructing 2,000 feet of close-piling.

* * * * * * *

Very respectfully, your obedient servant,

W. H. HEARDING,
Assistant Engineer.

Brevet Colonel J. B. WHEELER,
Major Corps of Engineers U. S. Army.

A 6.

OFFICE UNITED STATES ENGINEERS,
Milwaukee, June 30, 1868.

SIR: In compliance with your instructions of June 20, I respectfully beg to present you with a report upon the harbor of Manitowoc, Wisconsin:

Until artificial aid was rendered to the harbors on the west shore of Lake Michigan, there was not one along the entire coast to the southward of Green Bay which could offer the requisite facilities for carrying on a shipping business. With the exception of a few points, where deposits of boulders have arrested the abrasion of the banks by the waves, the shore line is straight; the rivers which discharge into the lake are small in comparison with the extent of the watershed of their surrounding districts; generally shallow at the mouth, which defect (as far as commercial interests are concerned) is chiefly due to the shifting character of the soil, which is loose and easily disturbed by storms, at the successive recurrence of which a deposit is invariably left in the natural channel of the river, which remains until the rain freshets have accelerated the velocity of the river current to such an extent as to cut out a new passage at their outlet.

One of the most prominent of these points juts out at a distance of about seven miles to the northeast of Manitowoc river, giving it protection from north and northeast storms.

The harbor of Manitowoc, which is at the mouth of the river, is situated

at the innermost part of the bight formed by the point in question. It is about equidistant from the straits of Mackinac and the southern extremity of the lake, 90 miles from Manitou islands, and the same distance from the entrance to Green Bay, which are the nearest natural harbors. It would therefore be desirable to make such improvements at this point as would secure to vessels the protection necessary to their safety during the heavy gales of wind which are prevalent on Lake Michigan in the spring and fall of the year.

Independent of its being of such general importance to the lake navigation, the success of the various industries in the vicinity of this harbor is dependent upon its capacity and the depth of the channel leading into it.

The benefit to be derived from its completion may be approximately estimated from the results which were obtained by the partial improvement which was effected last season. It is currently stated that the farmers sold their grain, which was shipped directly from this harbor, at an advance of six cents per bushel over the rates of sales which were made subject to the former distance of land carriage. Three hundred and fifty-three thousand nine hundred and forty-two bushels of wheat alone were exported last year, which yielded an extra profit to the farmer (assuming that such extra price was realized) of $21,236 52, and a proportionate gain was made on other articles of export. An idea of the increasing business and prosperity of this section of the country may be formed from the statement of one of the reliable business men of Manitowoc, that whereas it is now exporting large quantities of agricultural and various other products, it is but ten years since breadstuffs and other necessary supplies were imported.

Taking these facts into consideration in connection with extensive interests which are now in process of development, it would appear that the government was more than justified in finishing this work which has thus far been so satisfactorily prosecuted. It is capable of being made a permanent harbor of refuge. The adopted method of improvement is by the construction of parallel piers, one on each side of the channel, running from the mouth of the river in an easterly direction, to a sufficient depth of water in the lake. Sixty thousand dollars could be profitably expended at this harbor during the next fiscal year, which would without doubt insure its success as a permanent work. Twenty-five cribs were sunk last year, and the superstructure finished; 66 feet of superstructure was also built upon the old crib-work, commenced under Lieutenant Colonel J. D. Graham, topographical engineers, in 1855, forming a total of finished crib-work of 866 feet.

An extension of the pier was also made by close piling inside the river for a distance of 130 feet. This work was all done on the north side of the channel.

Thirteen cribs have been sunk on the south side during the present season, each 32 by 20 feet, and filled with stone to the water surface, upon which the superstructure will be built. So that the amount of crib-work and close piling constructed from July 1, 1867, to June 30, 1868, is as follows: 866 feet of finished crib-work; 416 feet of cribs built to water surface; 130 feet of close piling inside river; total, 1,412 feet lineal of pier.

Manitowoc is situated in the collection district of Milwaukee, which is also the nearest port of entry.

Nearest light-house, at the harbor; order of light, the fifth.

Mr. G. S. Rand has acted as foreman at this harbor, and it gives me

easure to state that he has performed his duty faithfully and to re satisfaction of the inspector.

avid Smoke, the contractor for framing, &c., has taken pains to perfect alignment of the piers, and the work generally has been ed in a creditable manner both to the contractors and to the ient.

e the honor to remain, very respectfully, your obedient servant,

W. H. HEARDING,
Assistant Engineer.

t Colonel J. B. WHEELER,
Major Corps of Engineers.

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tract of contracts for improving Manitowoc harbor, Wisconsin.

ntractors.	Nature of contract.	Prices paid.
ke	12-inch square pine timber, per lineal foot	$0 15
ke	12-inch hemlock timber, per lineal foot	14
ke	Stone, per cord, 128 cubic feet, in cribs	9 50
ke	Brush, per cord, 128 cubic feet, in intervals	2 00
ke	Framing, per lineal foot of timber	15
ke	Driving piles, each	3 00
ke	Placing and sinking cribs, each	90 00
ckard	Plank (oak) per M, (board measure)	25 00
ckard	Plank (pine) per M, (board measure)	18 00
ckard	Scantling per M, (board measure)	18 00
e	Dredging, per cubic yard	20
e	Pile timber, per foot	15
as	Iron bolts, per pound	7½
as	Iron spikes, per pound	12

f materials received, labor performed, and total amount paid, from July 1, 1857, to June 30, 1868.

emlock—lineal feet.	Plank, feet, b. m.	Piles, lineal feet.	Iron bolts.	Filling.		Dredging cubic yards.	Framing, lineal feet.	Cribs sunk.	Amount paid.
				Stone.	Brush				
13,028	10,320	7,649	64,424	*cords.* 2,002	*cords.* 326	62,092	84,813	38	$80,936 32

* 346 piles driven.

A 7.

OFFICE UNITED STATES ENGINEERS,
Milwaukee, June 30, 1868.

I respectfully beg to submit the following report upon the harbor oygan, Wisconsin:

harbor is situated upon the west shore of Lake Michigan, at a e of 25 miles south of Manitowoc.

n the collection district of Milwaukee, which place is also the port of entry. The nearest light-house is about one mile north arbor, with a fixed white light of the fifth order.

lan adopted for the improvement of this harbor is similar to that

which has been adopted at all the harbors on the west shore of Lake Michigan, viz: by constructing parallel piers from the mouth of the river from which the city of Sheboygan takes its name, to the navigable water of the lake, and dredging between them to the requisite depth.

The work will be of general benefit to the commerce of the lake when it is completed, as well as of great importance to the section of country westward. The projected railroad to St. Paul, Minnesota, via Fond du Lac, (20 miles of which is already finished,) will increase the business of Sheboygan largely; 130,049 tons of freight were transported over the completed section during the past year. The trade of the harbor has largely increased within that period, as will be seen by referring to the list of exports and imports, which increase is chiefly attributable to the improvement which has been already made to the harbor by the government. Ten cribs, each 32 feet in length by 20 feet in width, were sunk on the south side of the channel, and four on the north side—one of which was 25 feet in width and 32 feet in length—making a total length of finished pier-extension of 448 feet, upon which the superstructure has been built. Forty-five thousand dollars could be judiciously expended at this harbor during the next fiscal year, which would, without doubt, insure its permanency as a harbor of refuge.

Abstract of contracts for improving Sheboygan harbor, 1867.

Contractors.	Nature of contract.	Price.
Dillingham & Co	12-inch square timber, (oak,) per lineal foot	$0 27
Dillingham & Co	12-inch square timber, (pine,) per lineal foot	24
Dillingham & Co	Plank and scantling, per M, (board measure)	25 00
Dillingham & Co	Piles, (white oak,) per lineal foot	16
Locklin & Jenkins	Stone, per cord of 128 cubic feet	10 00
Sanger, Ledlie & Corse	Brush, per cord of 128 cubic feet	6 00
Sanger, Ledlie & Corse	Iron bolts, per pound	10
Sanger, Ledlie & Corse	Iron spikes, per pound	10
Sanger, Ledlie & Corse	Framing timber, per lineal foot	19
Sanger, Ledlie & Corse	Placing cribs, each	49 00
Sanger, Ledlie & Corse	Dredging, per cubic yard	49
Sanger, Ledlie & Corse	Driving piles, per lineal foot	19

Abstract of material received, labor performed, and total amount paid, from July 1, 1867, to June 30, 1868.

Timber.		Plank.	Piles.	Iron spikes.	Filling.		Dredging.	Framing.	Cribs placed.	Amount paid.
Pine.	Other.				Stone.	Brush.				
Lin. feet.	*Lin. feet.*	*Feet, (b.m.)*	*Lin. feet.*	*Lbs.*	*Cords.*	*Cords.*	*Cub. yds.*	*Lin. feet.*		
9,589	3,418	1,026	*330	95	498	49	28,928	29,237	14	$30,761 31

* 1,470 feet driven.

A new contract was entered into by Lucius R. Muzzy, on the 16th day of May, agreeable to the terms of advertisement dated April 23, 1868, for dredging at the harbor at Sheboygan. Mr. Muzzy being the lowest bidder, the contract was awarded him at 23½ cents per cubic yard; the county of Sheboygan furnishing the dredge.

Abstract of bids for dredging at Sheboygan harbor, 1868.

Bidders.	Residence.	Price per cubic yard.
John Schrage	Sheboygan	$0 24
O. B. Green	Chicago	50
B. B. Locklin	Sheboygan	27
E. W. Diercks	Milwaukee	31¾
Benjamin F. Price	Kenosha	36
Lucius R. Muzzy	Sheboygan	23½

The dredging under this contract is to be done outside of and in between the piers, the present depth of water not being sufficient to admit vessels which draw more than nine and a half feet of water.

I have the honor to remain, very respectfully, your obedient servant,

W. H. HEARDING,
Assistant Engineer.

Brevet Colonel J. B. WHEELER,
Major Corps of Engineers U. S. Army.

OFFICE UNITED STATES ENGINEERS,
Milwaukee, June 30, 1868.

SIR: I herewith respectfully submit a report upon the harbor of Milwaukee, Wisconsin:

Next to that of Chicago, this harbor is of the greatest commercial importance of any upon the west shore of Lake Michigan.

By a comparison of the soundings which were taken at the entrance to the harbor in June, 1867, with those which were taken in April, 1868, it was found that the "bar" in front of the harbor (which is common to all the rivers discharging into Lake Michigan) had considerably increased.

In June, 1867, the 12 feet line of curve on the north side of the channel was tangent to the prolongation of the inner line of the north pier, so that vessels could steer a straight course out of or into the harbor; but the storms during the winter extended the bank further to the southward, so that the bar inclosed by the curve line of 12 feet depth of water extended at the date of the last survey almost across the channel.

It is proposed to place out six cribs during the present season, in extension of the piers, each of which to be 50 feet in length by 25 in width, three on either side of the channel, forming an extension to each pier of 150 feet.

The piers should be extended to a still further distance of 250 feet on each side, which would insure a safe entrance to the harbor for many years.

The timbers above the water surface on a portion of the old crib-work are decayed, and a considerable outlay will be necessary to be made in repairs next season; $50,000 could be profitably expended at this harbor during the next fiscal year, in building the pier-extension and making repairs. By your instructions, I made a plan of a crib to be used at this harbor, 50 by 25 by 21 feet. The center longitudinal timbers of this crib are built up solid to the water surface, above which they alternate with the end timbers to the top, dividing the width of the crib into three

equal spaces. The center tier of cross-ties is solid to the top of the crib. In each case the solid timber-work is bolted in the same manner as the sides and ends.

Bill of materials proposed for a crib 50 by 25 by 21 feet; 47 yards of brush or slabs, to be placed in intervals between cribs; 24 yards of stone, to be placed over the brush; 450 feet (board measure) of 3-inch plank, for foot-walk; 9 pounds of six-inch spike.

Bill of materials proposed for a crib 50 by 25 by 21 feet.

No. of courses from bottom.	Timber, 12-inch square.							1¼-inch square iron bolts.			Stone, cubic yards.
	Lengths, in feet.							Amounts in lineal feet.	Lengths.		Weight, pounds.	
	20s.	30s.	23s.	27s.	25s.	46s.	44s.		20-inch.	32-inch.		
1	2	2	.....	.....	2	1	.....	196	.....	.....	.....	35.85
2	2	2	.....	.....	13	1	.....	471	58	.....	413.54	26.48
3	.....	.....	2	2	5	6	1	543	72	30	855.36	23.51
4	.....	.....	2	2	5	1	.....	271	.....	16	182.49	33.29
5	2	2	.....	.....	5	1	.....	271	.....	49	558.60	33.29
6	2	2	.....	.....	5	1	.....	271	.....	45	513.00	33.29
7	.....	.....	2	2	5	1	.....	271	.....	22	250.80	33.29
8	.....	.....	2	2	5	1	.....	271	.....	49	558.60	33.29
9	2	2	.....	.....	5	1	.....	271	.....	45	513.00	33.29
10	2	2	.....	.....	5	1	.....	271	.....	22	250.80	33.29
11	.....	.....	2	2	5	1	.....	271	.....	49	558.60	33.29
12	.....	.....	2	2	5	1	.....	271	.....	45	513.00	33.29
13	2	2	.....	.....	5	1	.....	271	.....	22	250.80	33.29
14	2	2	.....	.....	5	1	.....	271	.....	49	558.60	33.29
15	.....	.....	2	2	5	1	.....	271	.....	45	513.00	33.29
16	.....	.....	2	2	5	1	.....	271	.....	20	228.00	33.29
17	2	2	.....	.....	5	1	.....	271	8	37	478.84	33.29
18	2	2	.....	.....	5	1	.....	271	.....	35	399.00	33.29
19	.....	.....	2	2	5	1	.....	271	8	20	285.04	33.29
20	.....	.....	2	2	5	1	.....	271	.....	37	421.80	33.29
21	2	2	.....	.....	7	1	.....	321	28	35	598.64	33.29
Total	22	22	20	20	112	26	1	6,140	174	672	8,901.42	651.77

Cost of crib 50 by 25 by 21 feet at the awarded contract prices.

6,140 lineal feet of timber, at $16 75 per M., (board measure)	$1,234 14
8,901 pounds of wrought-iron bolts, at 4 cents per pound	356 04
676 cubic yards of stone ballast, at $2 26 per cubic yard	1,527 76
6,140 lineal feet of framing, at 13 cents per lineal foot	798 20
47 cubic yards of brush, at $1 04 per cubic yard	48 88
450 feet (board measure) of plank, at $16 75 per M.	7 04
9 pounds of 6-inch spikes, at 4 cents per pound	36
Total	3,972 24
Add 10 per cent. for contingencies	397 24
Total cost of 1 crib	4,369 66
Total cost of 6 cribs	26,217 96

The only work which was done at this harbor from July 1, 1867, to June 30, 1868, was the filling of the old cribs with stone, which was finished on the 12th day of September, 1867. On the 2d day of June, 1868, bids were received and opened for the work of improvement at this harbor during the present season, an abstract of which is herewith appended. The nearest light-house is situated at the north point of

Milwaukee bay, which is three miles distant from the channel leading to the harbor—with a lens of the fouth order, flashing at intervals of two minutes. It is at an elevation of 102 feet above the water level of the lake. There is also a beacon on the north pier at its present extremity, with a fixed red light; the lens is of the sixth order; its height above lake level is 48 feet, and is visible at a distance of about eight and a half miles.

Number of arrivals and departures of vessels &c., at Milwaukee harbor for the fiscal year ending June 30, 1868.

Arrivals, 6,078; tonnage, 2,209,513. Departures, 6,014; tonnage, 2,187,669. Duties on imports collected, $44,198 42. Tonnage duty collected, $10,421 58.

I have the honor to remain, very respectfully, your obedient servant,

W. H. HEARDING,
Assistant Engineer.

Brevet Colonel J. B. WHEELER,
Major Corps Engineers U. S. Army.

Abstract of contract for improving Milwaukee harbor in 1867.

Contractor.	Nature of contract.	Price.
Valentine Kuhlman.....	Stone per cubic yard	$2 70

Abstract of materials received and used, labor performed, and total amount paid, from July 1, 1867, *to June* 30, 1868, *at Milwaukee harbor, Wisconsin.*

Contractor.	Stone received and used.	For what paid.	Am't paid.
	Cubic yards.		
Valentine Kuhlman....	3,677.38	Stone.....	$9,928 90

Abstract of bids received and opened June 2, 1868, for improving the harbor at Milwaukee, Wisconsin.

No.	Bidders.	Residence.	First class.			Second class. Iron.		Third class. Filling.		4th class. Framing, per lin. ft.	Remarks.
			Timber.	Plank.	Piles, per lin. ft.	Bolts, lbs.	Spikes, lbs.	Stone.	Brush.		
				Per M.	*Cents.*	*Cents.*	*Cents.*			*Cents.*	
1	Edward Smith	Milwaukee				4½	4½				
2	E. D. Marsh & Co	Chicago	32½ c. per ft.	$28 00		8	8	$14 50 per cord.	$6 00 per cord.	13½	Placing and sinking cribs, $40 each; laying plank-walk, $20 per 1,000 feet.
3	C. H. Starke & Co	Milwaukee	24 c. per ft.			4	4	$11 00	$4 50	13½	Driving piles, $5 each; dredging, 50 cents per yard; repairing old timber, 5 cents; putting in new, 10 cents.
4	Valentine Kuhlman	Milwaukee						$2 32½ per cub. yd.	94 cts. per cub yd.		
5	Hasbrouck & Conro.	Milwaukee	$19 50 per M.		16	4	8	$12 00 per cord.	$5 00, slabs, per cd.	15	Dredging, 60 cents per yard; $2 per cord for putting in stone and slabs; framing, together with putting in stone, $13 per cord; for driving piles, $6 each.
6	Lee & Parker	Kenosha	26 c. per ft.	18 00	18	5½	8	$2 60 per cub. yd.	$1 25 per yard.	11½	Dredging, 40 cents inside, 80 cents outside; repairs, 15 cents per foot; driving piles, $4 each; putting in stone, 52 cents per cubic yard.
7	Carkin & Kimball	Milwaukee	21 c. per ft.	17 50	21	4½	10	$3 33 per cub. yd.	$1 00, slabs, per yd.	15	Dredging, $1 45 per cubic yard. Repairs, (engineer's estimate,) driving piles, $8; putting in stone, 25 cents per cubic yard.
8	Frank Buttrick	Milwaukee				4 7-10	4 7-10				
9	J. N. Sanders	Milwaukee						$2 24 per yard.			Placed in cribs, $2 74 per cubic yard.
10	E. W. Diercks	Milwaukee	$16 75 per M.		17			$2 26 per yard.	$1 04 per yard.		
11	H. Weide & Co	Milwaukee						$10 75 per cord.			
12	R. A. Conelly	Chicago	23 c. per ft.	18 00	18	7½	9½	$14 50 per cord.	$1 50 per cord.	14	Dredging, 57 cents per cubic yard; repairs, 23 cents per foot; driving piles, $3 each.
13	J. D. Dolan & Co	Milwaukee	22½ c. per ft.					$2 27 per yard.	$4 25 per cord.	13	
14	Fox & Howard	Chicago	25 c. per ft.	19 50		5	10	$14 00 per cord.	$5 00 per cord.	20	Dredging, 49 cents inside, 79 cents outside; hard pan, $1 20 per yard.
15	Ledlie & Corse	Chicago	23½ c. per ft.	19 00		4 7-10	8	$12 49 per cord.	$2 99, slabs, per cd.	19	Repairs, (engineer's estimates,) putting stone in cribs, 50 cents per yard.

Classes 1 and 3 awarded to bidders No. 10. Class 2 awarded to bidders No. 3. Class 4 awarded to bidders No. 13.

A 9.

OFFICE UNITED STATES ENGINEERS,
Milwaukee, June 30, 1868.

SIR: The harbor of Racine, upon which I have the honor to report, is situated at a distance of 23 miles S. by E. from Milwaukee. This harbor occupies quite an important position in the commercial interests of Wisconsin.

It is in direct communication with the Mississippi river, and with both branches of the Union Pacific railroad; the railroad from Racine forming a junction with the Mississippi and Missouri railroad at Rock Island.

The improvement at this harbor will be of general benefit to the lake commerce. The value of foreign and domestic imports and exports received and shipped during the fiscal year ending June 30, 1868, at this harbor, was $6,700,000.

During the season of 1867, 17 cribs were sunk, eight on the south side of the channel and nine on the north side. Late in the fall one of the cribs was destroyed by a severe storm, the timbers above the grillage bottom being twisted off. A new crib was constructed in the early part of this month, (June, 1868,) and after the foundation was leveled up with stone, was placed in the position formerly occupied by the crib which was carried away. A crib 32 feet square is in process of construction, which will be sunk shortly at the extremity of the north pier, and which will complete the work as far as the available means will admit. When this crib is sunk, and the superstructure is built upon the north pier-extension, there will have been constructed 576 feet total length of pier-extension. At present the work accomplished is as follows: 256 feet of pier-extension have been finished on the south side; 160 feet of pier-extension have been finished on the north side; 128 feet of pier-extension require finishing with superstructure. Total, 544 feet of pier-work finished and in process of completion.

The 32 feet square crib, when placed, will make the above-mentioned total length of 576 feet. It is expected that the whole will be finished by the 15th day of August next. Captain D. P. Heap, corps engineers, under whose immediate supervision the improvements at this harbor were made last year, recommended, in his annual report to you, that the south pier-extension should be carried out as far as the north; stating, as his reason for his making such recommendation, that if such extension was made the harbor would not probably need additional improvement of magnitude for years. I, therefore, respectively indorse his recommendation, believing that such improvement would place the harbor in such a condition as to meet the requirements of trade for many years to come. His estimate for doing this work is $42,817 42.

Racine is in the revenue district of Milwaukee, which is also the nearest port of entry. The nearest light-house is situated on the pier on the north side of the harbor channel, with a lens of the fifth order, white fixed light, 47½ feet above lake-level.

I have the honor to remain, very respectfully, your obedient servant,

W. H. HEARDING,
Assistant Engineer.

Brevet Colonel J. B. WHEELER,
Corps Engineers United States Army.

Abstract of contracts for improving the harbor of Racine, Wisconsin, August 1866.

Contractors.	Nature of contract.	Price.
James V. Sanger, James H. Ledlie, and John M. Corse	White-oak piles, per lineal foot	$0 1
	Plank, per thousand, (board measure,) 3-inch	30 0
	Scantling, per thousand, (board measure)	30 0
	Twelve-inch square timber, per lineal foot	2
	Iron bolts and spikes, per pound	1
	Brush, placed in intervals between cribs, per cord	6 0
	Stone, in cribs, per cord	13 8
	Placing cribs, each	39 0
	Driving piles, per lineal foot	1
	Framing, per lineal foot	1
	Dredging, per cubic yard	4
	Repairs to be paid at engineer's estimates.	

Contracts of June, 1867.

Contractors.	Nature of contract.	Price.
P. M. Danaher	Twelve-inch square timber, per thousand, (board measure)	$14 97
P. M. Danaher	Three-inch plank, per thousand, (board measure)	14 97
P. M. Danaher	Framing, per lineal foot of timber	13
Ledlie and Corse	Stone, per cubic yard	2 69
Ledlie and Corse	Brush, per cord of 128 cubic feet	5 40
R. Nelson Gere	Wrought-iron bolts, per pound	5
R. Nelson Gere	Wrought-iron spikes, per pound	7

Abstract of materials received, labor performed, and total amount paid, at Racine harbor, July 1 1867, *to June* 30, 1868.

Timber.	Plank.	Piles.	Iron.		Filling.		Dredging.	Framing.	Cribs sunk.	Amount paid
			Bolts.	Spikes.	Stone.	Brush.				
Lin. feet.	*Ft. (B. M.)*		*Lbs.*	*Lbs.*	*Cords.*	*Cords.*	*Cub. yds.*	*Lin. feet.*		
44,555	2,602		43,618	260	1,841	139	6,912	46,111	17	$46,589 2

A 10.

KENOSHA HARBOR.

Kenosha, Wisconsin, is a thriving town on the west shore of Lak Michigan, 34 miles south of Milwaukee; it is in the collection district o Milwaukee. Racine is the nearest port of entry.

The light-house is situated on Warrenton island, on the north bank o the river. The light is fixed, varied by flashes at intervals of one minut and thirty seconds, and is visible 14 nautical miles. The color of th tower is yellow, and the tower is 55 feet high. The light is 76 feet abov the sea level; the lens is of the fourth order. The light-house was buil in 1848, and was rebuilt in 1866.

The commerce and navigation benefited are both local and general. There is a large basin at a short distance from the mouth of the river, perfectly protected from all winds. If this basin was dredged out to a depth of 12 feet, it would make a most excellent and spacious harbor of refuge.

The present plan of improvement is to dredge out the channel between the piers to a depth of 12 feet, to extend the north pier 192 feet, and the south pier 352 feet. Owing to bad weather last year this improvement was not entirely finished; the superstructure of the north pier is yet to be built. This can easily be done this year. I would recommend that each pier be further extended 224 feet, and that the old pier-work, especially that on the south side, be repaired. The cost will be—

448 feet of pier extended	$50,000
1,200 feet of old pier repaired	20,000
Total	70,000

This amount, I think, will suffice to permanently complete the work, with the exception of occasional dredging between the piers, unless it be deemed advisable to dredge out the basin, which would cost $20,000.

I append abstract of contracts, work, &c.

Very respectfully, your obedient servant,

D. P. HEAP,
Captain of Engineers.

Abstract of contracts for improving the harbor of Kenosha, Wisconsin.

Contractors.	Nature of contract.	Price.
James V. Sanger, James H. Ledlie, and John M. Corse	Piles, per lineal foot	$0 19
	Oak plank, per thousand, (board measure)	35 00
	Pine plank, per thousand, (board measure)	30 00
	Twelve-inch square timber, pine, per lineal foot	29
	Twelve-inch square timber, oak, per lineal foot	39
	Iron bolts and spikes, per pound	10
	Brush, in cribs, per cord	5 00
	Stone, in cribs, per cord	13 87
	Driving piles, per lineal foot	13
	Framing, per lineal foot	10
	Placing cribs, each	39 00
	(Repairs to be paid for at rates fixed by engineer officer in charge.)	
Caleb H. Parker	Dredging between piers and for foundation of cribs, per cubic yard	37
Caleb H. Parker	Dredging on bars or points outside of proposed extension	74

Abstract of material received and work done at Kenosha harbor from July 1, 1867, to June 30, 1868.

36,607 lineal feet of timber; 7,900 feet (board measure) of plank; 50 cords of brush; 1,027¼ cords of stone; 76,257 pounds of iron; 207 pounds of spikes; 40,750 lineal feet of timber framed; 17 cribs placed; 68,420 cubic yards of dredging.

The resulting length of pier is that proposed by the plan. Both piers are now of equal length. The depth of water between the piers is 15 feet.

A 11.

CHICAGO HARBOR.

Chicago, Illinois, is situated in Cook county, at the mouth of the Chicago river; it is in the collection district of Chicago, and is itself a port of entry.

Number of vessels arriving at this port from July 1, 1867, to July 1, 1868, 12,194; tonnage, 2,790,446; seamen, 113,551.

Number of vessels cleared from this port from July 1, 1867, to July 1, 1868, 13,026; tonnage, 2,789,116; seamen, 114,095.

Amount of revenue collected during fiscal year ending June 30, 1868.

Duties paid in coin	$659,409 48
Revenue paid in currency	36,139 56
Total	695,549 04

Mr. Walter B. Scates, collector of customs at Chicago, was kind enough to furnish me with the above information.

The light-house is placed on the pier, near the outer end, in latitude N. 41° 53′ 25″; longitude W. 87° 36′ 56″. The light is fixed, and is visible 15 nautical miles. The tower is built of iron; is black, and 72 feet high. The height above sea level is 83 feet. The lens is of the fourth order. The tower was built in 1859.

The commerce and navigation benefited are very general, as this is the port from which a great proportion of the grain grown in the west is shipped to the east, and as, also, it is one of the few harbors, near the southern end of Lake Michigan, in which shelter can be obtained during a storm.

The original plan of improvement was to extend the north pier 600 feet, and to do such dredging as necessity should require. Instead of commencing this extension immediately at the end of the old north pier, it was commenced 300 feet from the pier, leaving this opening as an entrance to the basin now being built by the Chicago Dock and Canal Company. The Chicago Dock and Canal Company, in consideration of this opening being left for their benefit, agreed to assume any expense which might accrue to the contractors through the departure from the original plan.

The same benefit will be obtained now by extending the pier 300 feet as by adopting the old plan of a 600 feet extension; consequently I do not think it would be advisable at present to build more than 300 feet of pier on the north side.

The bar at the mouth of the harbor increased considerably last winter, owing, in a great measure, to the Chicago Dock and Canal Company not inclosing their basin in time, according to agreement. I have measured the amount of increase and find it to be a little over 4,000 cubic yards. The company agree either to pay for its removal or have it removed themselves.

Other dredging should be done, and if it is determined that the government is to do it, and also to extend the south pier, then $60,000 could be expended during this fiscal year.

The plan of improvement at this harbor, as well as at every other, can be, from its nature, but transient in its effect. We can hope for no permanent improvement until we accomplish the impossibility of arresting or changing the action of the wind on the waves. Until we do this, the inevitable bar will form sooner or later at the mouth of every harbor. All that is in our power to do is to retard its formation as long as possible.

I append abstracts of contracts, work, &c.

Very respectfully, your obedient servant,

D. P. HEAP,
Captain of Engineers.

Abstract of material received and work done at Chicago harbor from July 1, 1867, to June 30, 1868.

54,555 lineal feet of timber; 865¼ cords of stone; 76 piles; 20,946 lineal feet of timber framed; 76 piles driven; 4,319 iron bolts used; 865¼ cords stone of used.

Ninety-six feet of pier-work have been finished. This small amount of pier-work finished is due to the delay occasioned to the contractors by the building of the Chicago Dock and Canal Company's basin. As this delay was not the fault of the contractors, they were allowed one year longer to fulfill their contract.

There were 3,152 cubic yards of dredging done.

Abstract of contract for improving harbor at Chicago, Illinois.

Contractor.	Nature of contract.	Price.
John M. Corse	Twelve-inch square timber, per lineal foot	$0 28
	Three-inch plank, per thousand feet, (board measure)	31 75
	Brush, per cord	5 74
	Stone, per cord	8 74
	Delivering and driving white-oak piles, each	11 98
	Framing and sinking cribs, per lineal foot	11¼
	Iron bolts, per pound	9¼
	Iron spikes, per pound	14¼
	Dredging inside of piers, per cubic yard	44
	Dredging outside of piers, per cubic yard	74

A 12.

MICHIGAN CITY HARBOR.

Michigan City, Indiana, is situated at the southern end of Lake Michigan, and is the only lake port of Indiana.

It is in the collection district of Chicago, Illinois, which is also the nearest port of entry. The light-house is in latitude 41° 43′ 23″; longitude west, 86° 54′ 20″. The light is fixed, and is visible 11 nautical miles; the tower is yellow, and is 34 feet high; the light is 52 feet above

sea level; the lens is of the fifth order. The tower was built in 1837, and rebuilt in 1858; the light is on the keeper's dwelling. The commerce and navigation benefited are both local and general. Large amounts of iron ore have been brought here lately from Lake Superior; there is a respectable lumber trade carried on; and, besides, when this harbor is completed it will make an important harbor of refuge.

The present plan of improvement is to extend the east pier 288 feet, and the west pier 320 feet, thus making both of equal length.

The government is dredging out the channel. The present appropriation, $75,000, is sufficient to complete this plan of improvement, and this sum can properly be expended during this fiscal year. The work was let on the 7th of August, 1867.

The contract for timber and framing was awarded to Francis C. Slater, of Chicago. By his contract he was required to place four cribs last year; up to 7th of February, 1868, he had delivered no timber and done no framing. On this date the contract was taken from Slater and given to J. D. Dolan, of Milwaukee. The district attorney of Chicago, Hon. Jesse O. Norton, has been directed to prosecute Mr. Slater for the non-fulfillment of his contract. I do not think it advisable to extend the piers any farther than contemplated by the present plan; no matter how long they may be, they will not prevent the sand, brought by the violent northerly storms, from being washed in between them. An expense of from $2,000 to $5,000 will probably have to be incurred each year to pay for the dredging necessary to keep the harbor open. I would recommend that the north bank of the river be sheath-piled from the bend to above the bridge, a distance of 1,350 feet, and the river dredged to a depth of 12 feet for this same distance. If this be done it will improve the harbor greatly, making it more roomy, and affording a safer anchorage for vessels than now exists between the piers, as the channel there is directly exposed to northerly winds, and as being an unsafe place for vessels of heavy draught to lie during a storm. I have made estimates of the cost of sheath-piling and dredging, and find them to be:

Sheath-piling	$10,672
Dredging	24,750
Total	35,422

If this sum was appropriated it could be profitably expended during this fiscal year. The amount of earth dredged last year by the government was 17,744 cubic yards, at a cost of $4,674 66, being 32 cents per cubic yard. The following extracts from a letter written to me by Mr. Ensign Bennett will show the expenses up to 1st of July this year:

"You will notice, in the returns of work done at Michigan City, that the amount of material actually removed and deposited in Lake Michigan up to the 1st of July, is 20,940 cubic yards, and that the expenses attending the dredging, up to the same date, had been $4,801 57, or nearly 23 cents per cubic yard. Of this sum $1,750 is fairly chargeable for the repairs of the dredge and dump-scows, thus reducing the actual expenses of dredging to a fraction over 14 cents per cubic yard.

"Still another deduction ought to be made for time lost in dredging a channel of sufficient depth to load scows, and also for the time consumed in opening a cut for the passage of the dredge from the place where it was laid up last winter to deeper water near the mouth of the harbor, where the dump-scows could be used. The dredge commenced work on

this cut on the 1st of April, and it was not until the afternoon of the 20th of April that the scows could be used; meantime the material dredged was necessarily cast to the side of the cut. It is probable that not less than 8,500 cubic yards were moved in this manner, for which no credit is given."

When it is borne in mind that at least one-third of the material dredged has been tough clay, the cost may be considered as within reasonable limits. I desire to bear testimony to the efficiency of Mr. Ensign Bennett, United States foreman at Michigan City and New Buffalo. He has superintended the government work at those places with great care and ability, and has given satisfaction both to his employers and to the citizens of those towns.

I append abstracts of bids, contracts, &c.

Very respectfully, your obedient servant,

D. P. HEAP,
Captain of Engineers.

Abstract of bids for improving the harbor at Michigan City, Indiana.

Contractor.	Nature of contract.	Price paid.
Francis A. Slater, Chicago.	12-inch square timber.	14 cents per lineal foot.
	Iron bolts	7½ cents per pound.
	Stone	$2 66½ per cubic yard.
	Framing	13 cents per lineal foot.
J. D. Dolan, Milwaukee	12-inch square timber.	15 cents per lineal foot.
	3-inch plank	16 cents per lineal foot.
	Iron bolts	6 cents per pound.
	Iron spikes	8 cents per pound.
	Stone	$2 62½ per cubic yard.
	Brush	75 cents per cubic yard.
	Framing	17 cents per lineal foot.
Galen Eastman, Grand Haven.	12-inch square timber.	$17 9 per lineal foot.
	3 inch plank	$15 75 per 1,000 feet, (board measure.)
	Iron bolts	5.9 cents per pound.
	Iron spikes	7.9 cents per pound.
	Stone	$2 90 per cubic yard.
	Brush	60 cents per cubic yard.
	Framing	24 cents per lineal foot.
George Hannahs, South Haven.	12-inch square timber.	16¾ cents per lineal foot.
	Framing	14¾ cents per lineal foot.
M. G. Sherman, Michigan City.	12-inch square timber, (pine)	19 cents per lineal foot.
	12-inch square timber, (other)	17 cents per lineal foot.
	3-inch plank	$16 per 1,000 feet, (board measure.)
	Iron bolts	5 cents per pound.
	Iron spikes	8½ cents per pound.
	Stone	$3 18 per cubic yard.
	Brush	$1 25 per cubic yard.
	Framing	17 cents per lineal foot.
Chapin & Wells, Milwaukee.	Iron bolts	4¼ cents per pound.
Hasbrouck & Conro, Milwaukee.	Iron spikes	6½ cents per pound.
	12-inch square timber	20 cents per lineal foot.
	Iron bolts	7 cents per pound.
	Stone	$15 per cord.
	Brush	$6 per cord.
	Framing	15 cents per lineal foot.

Abstract of bids, &c.—Continued.

Contractor.	Nature of contract.	Price paid.
James H. Mallory, Elgin, Kane county, Illinois.	12-inch square timber	21½ cents per lineal foot.
	3 inch plank	$24 per 1,000 feet, (board measure.)
	Iron bolts	5¾ cents per pound.
	Iron spikes	13 cents per pound.
	Stone	$15 90 per cord.
	Brush	$6 per cord.
	Framing	13½ cents per lineal foot.
Silver & Bower, Michigan City.	12-inch square timber	18 cents per lineal foot.
	Iron bolts	5½ cents per pound.
	Stone	$15 75 per cord.
	Framing	19½ cents per lineal foot.
Barker & Roberts, Michigan City.	12-inch square timber	18 cents per lineal foot.
	3-inch plank	$16 per 1,000 feet, (board measure.)
	Iron bolts	4.9 cents per pound.
	Iron spikes	8 cents per pound.
	Stone	$15 50 per cord.
	Brush	$3 per cord.
	Framing	18 cents per lineal foot.

Abstract of contract for improving harbor of Michigan City, Indiana, August, 1867.

Contractors.	Nature of contract.	Price.
J. D. Dolan	Stone, per cubic yard	$2 62½
J. D. Dolan	Brush or slabs, per cubic yard	75
F. A. Slater	12-inch square timber, per lineal foot	14
F. A. Slater	Framing, including placing, sinking, and filling cribs	13
Chapin & Wells	Iron bolts, per pound	04⅞
Chapin & Wells	Iron spikes, per pound	06½

Abstract of contract for improving harbor of Michigan City, February 7, 1868.

Contractor.	Nature of contract.	Price.
		Cents.
J. D. Dolan	12-inch square timber, per lineal foot	15
	3-inch plank, per lineal foot	16
	Framing, per lineal foot	17

Abstract of material received and work done during the last fiscal year.

Four hundred and fifteen cords of stone; 24,193 pounds of iron; 38,684 cubic yards dredging. No timber has been received, and no framing has been done.

The dredging has opened and kept open a channel 12 feet deep the whole length of the piers.

MILWAUKEE, WISCONSIN, *February* 8, 1868.

GENERAL: I have the honor to submit this as a supplementary report upon Michigan City harbor, to be added to those already on file at headquarters of the corps of engineers. In making this report I kept in view that the improvement of this harbor is merely for the trade of Michigan City, and shelter for those vessels accidentally caught by stress of weather in its vicinity.

The commerce of Michigan City is increasing, and will grow rapidly if this improvement should be made, and the large number of vessels sailing on this lake assures us that a storm rarely happens during the season of navigation that does not catch some of them in the vicinity of this harbor. A harbor of sufficient capacity and safety, where they might seek refuge under such circumstances, would be essentially necessary for them. I have confined my plans and estimate in previous reports to deepening the straight channel from the lake to the river to 12 feet, and extending the piers to the same depth of water in the lake. The experience of the past autumn and present winter has shown the necessity of further improvements to be made in order to make this a safe harbor.

I found last fall that vessels lying in the straight channel between the piers were subject to injury caused by the heavy swell of the lake running in the harbor during northerly storms, and to secure the dredge and scows, we brought them around the point, near B, on the attached sketch, in the bend of the river. To secure those vessels in the harbor, or those running into this harbor for safety, it is necessary that they should round this point. A channel of not less than 10 feet was made by dredging during the past year between the piers. At present a depth of about seven feet exists. This blocking up or filling of the channel has been caused by the sand-drift from the northeast, partially deposited by the littoral current behind the weather pier, but deposited mostly by the current of the river, that brings down all that is blown over by the force of the wind and that part worn from the bank by the stream. To make this harbor useful we must cut off this point, as marked by the dotted red line on the sketch from B to F, sheath-pile along the north bank of the river for 1,350 feet, and deepen the river by dredging throughout its full width, from its mouth to the upper end of the piling, near E.

This will allow vessels to sail around the bend and be secure during a northerly gale. The piling will prevent in a great measure the filling up of the channel, and if board-fencing be placed, or shrubbery and grass be made to grow on the ridge of sand running parallel to the river, the drift caused by the northerly winds may be checked and the channel might be kept open for a long time. This point was partially removed and a portion of the sheath-piling driven, under the direction of either Colonel Graham or Mr. Bowes. The estimated cost of these is as follows:

Removing point and deepening channel of river	$24,750 00
For 1,350 feet sheath-piling	10,672 50
Total	35,422 50

I would, therefore, respectfully request that this additional amount be asked for in order to make Michigan City harbor suitable for the purposes intended, viz: suitable for its particular commerce, and a refuge for those vessels caught in a storm when in its vicinity.

For detail estimates, I would refer to the report of Captain D. P. Heap, United States engineers, herewith attached.

I am, general, very respectfully, your obedient servant,

J. B. WHEELER,
Major of Engineers and Brevet Colonel.

Major General A. A. HUMPHREYS,
Chief of Engineers, Com'dg Corps of Engineers U. S. A.,
Washington, D. C.

MILWAUKEE, WISCONSIN, *February* 4, 1868.

COLONEL: I have the honor to submit the following report on Michigan City harbor:

During last summer the straight cut A B, (see accompanying tracing,) was dredged sufficiently deep to allow large vessels to enter the harbor and lie at either pier. There was also dredging done from B to C to secure the dredge and scows a safe place to lie during the winter. After the dredging was stopped, the channel A B filled up considerably, partly, I think, from the sand being washed in the mouth of the harbor, but also, in a great measure, from sand being carried down by the creek. The whole north bank of this creek is composed of fine sand, is but very slightly protected by shrubbery, and is continually being cut away by the action of the water. There used to be a few trees growing to the north of the Michigan Central railroad round-house, but these have been removed to give air to the work-shops.

So long as the north bank is left unprotected, just so long will the creek continue depositing its sand between the piers, thus necessitating dredging every year. To obviate this I would propose that this bank be sheath-piled from the point B to E, and the creek dredged to a depth of 12 feet for the same distance; the point A should be cut off on the dotted line shown in the tracing from B to F. The distance from B to E is 1,350 feet; the average depth of water at present is two feet. The citizens propose to use the bank from B to D for docks, and will probably commence building these docks as soon as the channel is dredged to the proper depth; if they do so it will only be necessary to sheath-pile from the bridge to E, a distance of 600 feet. As the harbor is at present, even with a proper depth of water between the piers, vessels cannot lie with safety alongside of them, as the piers afford no protection to northerly winds, which are the most violent that this harbor is exposed to.

If the creek is dredged the distance proposed, a safe anchorage for a large number of vessels is at once obtained, and until this is done, and the sand prevented from coming down the creek, the harbor will be continually getting choked up, and will not be of much use when open.

I append estimates of the probable cost of the dredging and sheath-piling.

Very respectfully, your obedient servant,

D. P. HEAP,
Captain of Engineers.

Major and Brevet Colonel J. B. WHEELER,
Corps of Engineers.

e of the cost of 1,350 feet of sheath-piling at Michigan City, Indiana.

s, 12 inches square and 30 feet long = 4,080 lineal feet, cents	$612 00
k planks, 4 by 8 inches by 26 feet = 126,256 feet, (board re,) at $18	2,272 60
eal feet of 12-inch square timber for land ties; 1,360 feet of 12-inch square timber for ground sills; 1,360 feet of 12-inch square timber for caps; 1,360 lineal f 12-inch square timber for stringers=6,800 lineal 2-inch square timber, at 20 cents	1,360 00
inds 9-inch spikes, at 10 cents	380 00
inds of 1½-inch square bolts, 20 inches long, at 6 cents,	391 68
136 piles, at $4	544 00
1,821 sheath piles, at $2	3,642 00
f framing	500 00
	9,702 28
er cent. for contingencies	970 22
	10,672 50

D. P. HEAP,
Captain of Engineers.

of amount of dredging required at Michigan City harbor, Indiana, in accordance with the foregoing report.

proposed to be dredged, 1,350 feet; average depth er at present, 2 feet; proposed width of channel, 100 lepth to be obtained, 12 feet; number of cubic yards erial to be removed, 50,000; cost per cubic yard, 45 total cost	$22,500 00
er cent. for contingencies	2,250 00
and total	24,750 00

D. P. HEAP,
Captain of Engineers.

A 13.

NEW BUFFALO HARBOR.

arbor is situated in Michigan, about nine miles to the east of
i City.
uffalo is in the collection district of Chicago, Illinois, which is
nearest port of entry; the nearest light-house is at Michigan
vessels sail to or from this harbor; if it were put in a suitable
i it would make a good harbor of refuge, but still would neces-
eat expense.
resent improvement consists of cutting through the low sand-
reen Lake Pottawatomie and Lake Michigan, extending the cut
o the former lake, and close sheath-piling the sides of the cut.

The cost of this improvement was estimated to be $384,000; $60,000 was appropriated, of which about $30,000 have already been expended. If it is determined to continue this work, the remainder can properly be expended during this fiscal year.

On the 30th of last June the cut had been carried through to the lake three times, and each time its mouth was closed up again by the action of the waves.

I think that the best way to remedy this is to build two piers, each 100 feet long, extending into Lake Michigan from both sides of the cut. A pile-pier, similar to that used at St. Joseph, Michigan, would be most economical.

To permanently improve the harbor these piers would each have to be further extended 500 feet, so as to reach 12 feet water in the lake, and the channel would have to be dredged to this depth; after this is done it would be necessary to dredge a basin in Lake Pottawatomie of sufficient size to admit a number of vessels, so as to render the harbor useful as a harbor of refuge. These improvements would cost in the neighborhood of $500,000. As the waves would be continually filling the mouth of the harbor with sand, from $3,000 to $8,000 would have to be spent yearly in dredging out the channel.

In view of these facts I would recommend that the work be stopped, and that the material bought by the government be sold.

I append abstracts of work, contracts, &c.

Very respectfully, your obedient servant,

D. P. HEAP,
Captain of Engineers.

Abstract of work done and material received at New Buffalo, from July 1, 1867, to June 30, 1868.

Work done: dredging, 70,563 cubic yards.

Material received: 63,288 feet timber, board measure; 40,500 lineal feet piles; 14,659 pounds iron.

NOTE.—The dredging done consists of a cut through the sand-hill to Lake Michigan and extending back into Lake Pottawatomie, making in all a cut about 1,400 feet long, 40 feet wide, and six feet deep.

None of the materials received have as yet been used.

Abstract of contract for improving harbor of New Buffalo, Michigan.

Contractors.	Nature of contract.	Price.
Carkin & Kimball	Dredging, per cubic yard, in soft material	$0 34
	Piles, per lineal foot	08
	Timber, per M, (board measure)	15 00
	Plank, per M, (board measure)	16 00
	Stone, per cord of 128 cubic feet	15 75
	Slabs, per cord of 128 cubic feet	2 90
	Framing, per lineal foot	08½
	Driving piles, per lineal foot	06½
	Dredging, per cubic yard, in hard material	70
R. Nelson Gere	Iron bolts, per pound	04⅝

A 14.

ST. JOSEPH HARBOR, MICHIGAN.

St. Joseph is situated on the east shore of Lake Michigan. It is in the collection district of Grand Haven, and the nearest port of entry is Grand Haven.

The light-house is placed at the mouth of St. Joseph's river, south side. The light is fixed, varied by flashes at intervals of one and a half minute, and is visible 15 nautical miles. It is placed on the keeper's wooden dwelling, which is painted white. The height of the tower is 35 feet, and its height above sea level, 90 feet. It was first built in 1831; rebuilt in 1859. The lens is of the fourth order.

The commerce and navigation benefited are both local and general. St. Joseph is the port from which an immense amount of fruit is shipped yearly, and the harbor when improved will make a fine harbor of refuge.

The north pier is 1,100 feet long. During last fiscal year the south pier was extended 200 feet. This extension consists of a pile pier, and is now finished, with the exception of filling the last two sections with stone. These sections were nearly filled once, but a violent storm arose while the men were at work, and the stone was washed out. I would recommend that the south pier be extended 700 feet further, thus making it equal in length to the north pier. If this extension be built on piles, it will cost $50,000; if built of cribs, the cost will be $80,000. If this work is commenced soon one-half of it could easily be finished during this fiscal year. The channel now is close to the south pier. On leaving the end of this pier it tends nearly due south, and a bar has extended from the end of the north pier nearly across the mouth of the harbor, thus making the entrance very difficult, especially to sailing-vessels, which is to be deplored, for with an easy entrance this would make a fine harbor of refuge. When both piers are of equal length this bar will be in a great measure removed by the current, which is quite rapid.

I append abstracts of contracts, material received, &c.

Very respectfully, your obedient servant,

D. P. HEAP,
Captain of Engineers.

Abstract of contract for improving the harbor at St. Joseph, Michigan.

Contractor.	Nature of contract.	Price.
Hasbrouck & Conro.....	Oak piles, each.....	$16 00
	Pine timber, per cubic foot.....	35
	Brush, per cord.....	3 00
	Stone, per cord.....	15 00
	Iron bolts, per pound.....	10
	Iron bolts with nut and screw, per pound.....	18

NOTE.—All material to be considered as received must have been used in the work.

Abstract of materials received and used and labor performed at the harbor of St. Joseph, Michigan.

17,088 cubic feet timber; 904 cords stone; 324 cords brush; 24,330 pounds drift bolts; 6,991 pounds screw bolts; 187 piles driven.

The resulting length of pier is 200 feet.

A 15.

SOUTH HAVEN HARBOR, MICHIGAN.

South Haven, Michigan, is 25 miles north of St. Joseph. It is in collection district of Grand Haven, which is also the nearest por entry. The nearest light-house is at Kalamazoo, Michigan. Priv enterprise maintains a beacon-light on the south pier.

The commerce benefited by improving this harbor is mainly lo South Haven being the outlet of the lumber districts of the countie Allegan and Van Buren, there is a large quantity of fruit, especi peaches, shipped from here each year. South Haven is an enterpri place, and has nearly doubled in size within the last twelve months. present plan of improvement consists in extending the piers until t reach 12 foot water, which requires each pier to be extended 320 feet would recommend that each pier be further extended 128 feet. thousand dollars of the appropriation are still on hand. This sum properly be expended this summer and fall.

The piers are now in good condition, though the cribs have sett rather irregularly. This spoils their appearance, but does not injure t efficacy.

The channel varies in depth according to the direction of the w During a storm from the north the sand is brought around the end of north pier and deposited in the mouth of the river. When the north is equal in length to the south pier, I think that this deposit will materially lessened.

While the weather is calm the river current deepens the channel siderably, but not entirely across between the piers, so I think it ad able after the piers are built that about $5,000 be expended in dredg

I append abstracts of contracts, &c.

Very respectfully, your obedient servant,

D. P. HEAP,
Captain of Engineer

Abstract of contract for improving harbor at South Haven, Michigan

Contractors.	Nature of contract.	Pr
Galen Eastman	12-inch square timber, per M, (board measure)	$13
Galen Eastman	3-inch plank, per M, (board measure)	15
Galen Eastman	Piles, per lineal foot	
Galen Eastman	Stone, per cord	14
Galen Eastman	Brush	2
R. Nelson Gere	Iron bolts, per pound	
R. Nelson Gere	Iron spikes	
George Hannahs	Framing, per lineal foot	

Abstract of materials received and work done from July 1, 1867, *to J* 30, 1868.

Material received: Stone, 1017 cords; timber, 44,488 lineal feet; br 135 cords; iron, 69,516 pounds.

Work done and material used: Timber framed, 29,657 lineal feet; br 135 cords; stone, 1017 cords; iron, 39,141 pounds.

There are now 12 cribs placed, 8 of them on the south side; on this side the superstructure has been commenced. The contractor is rapidly extending the north pier.

A 16.

BLACK LAKE, MICHIGAN.

Black lake is 22 miles south of Grand Haven. Holland, the only village on the lake, is six miles from the mouth. It is in the collection district of Michigan, and the nearest port of entry is at Grand Haven. The nearest light-house is at the mouth of the Kalamazoo river, eight miles to the south; it is a fixed light of the sixth order. The amount of revenue collected for this year is $691 31. Number of arrivals and departures of vessels is 1,082. The benefits to commerce and navigation arising from this improvement will be both general and local. The country around Black lake is thickly settled by industrious Hollanders, who are building up for their village a fine trade. A company has been organized to build a railroad from Holland to Kalamazoo, Michigan, connecting with the Michigan Central and Southern railroads. It is to be completed by July 4, 1869. This will open a new channel of communication between the east and west, and render the harbor of Black lake of considerable importance. The plans for the improvement of this harbor were given in full in October, 1866. They were, to extend north pier 250 feet and south pier 275 feet; at entrance to Black lake the channel was to be close-piled, 1,125 feet on north side and 425 feet on south side; a row of close-piling was to be driven in front of old brush-work through cut, and the whole channel was to be dredged to a depth of 12 feet. The cost of entire work was estimated at $106,615 31. This amount has been appropriated and will be sufficient to complete the work in a permanent manner.

Dredging was commenced August 6, 1867, and during last season 81,945 cubic yards were removed. During same time 893¼ square yards (30 feet wide and 268 feet long) of sink-pieces were placed, and three cribs sunk; one crib not being properly filled with stone washed into the channel, where it now remains. Work was resumed March 19, 1868, and up to date the following work has been done: There have been placed on north side, in addition to the three placed last year, four cribs, and one in place of the crib washed into channel on the south side; four cribs have been sunk, and in the gaps of old piers, made by the ice, two; 882 square yards of sink-pieces have been placed, and 22,650 cubic yard dredged. No superstructure has yet been built. The cribs on north side stand well, and when built up will present a very creditable appearance. On the south side the first three cribs are placed on the sand and not on sink-pieces. Nos. 1, and 2 have settled unevenly and are a little out of line. Nos. 3 and 4 are level. The channel continues to deepen as the work progresses, and vessels drawing seven or eight feet can enter with ease.

The close piling at Black lake and of channel, especially that on north side, is very necessary to prevent a wash of sand. The point thus to be protected is the one from which the sand heretofore obstructing the channel has been washed.

This work will be completed by end of August this year.

I am, very respectfully, your obedient servant,

A. MACKENZIE,
Captain United States Engineers.

Brevet Colonel J. B. WHEELER,
Major of Engineers U. S. Army.

Abstract of contract for improving harbor of Black lake, Michigan.

Contractors.	Nature of contract.	Price.
John Roost	12-inch timber, per line foot	$0 20
John Roost	3-inch plank, per M, (board measure)	25 00
John Roost	Sink-pieces placed, per square yard	3 70
S. N. Kimball	Stone, per cord of 128 cubic feet	13 40
S. N. Kimball	Brush, per cord of 128 cubic feet	3 00
J. H. Ledlie	Iron bolts, per pound	06.9
J. H. Ledlie	Iron spikes, per pound	15
J. E. Miller	Framing, per lineal foot of timber	09
J. E. Miller	Filling with stone, per cord	80
J. E. Miller	Dredging in ordinary material, per yard	34½
J. E. Miller	Dredging in hard-pan or stiff clay, per yard	69

Abstract of materials received, used, and labor performed, at Black lake, Michigan, from June 30, 1867, to June 30, 1868.

Material received and labor performed: Timber, 55,296; plank, 4,608; stone, 571; brush, 80; iron, 56,012; dredging, 104,595; framing, 22,650; sink-pieces placed, 1,775½; cribs placed, 11.

Materials used: Timber, 22,650; stone, 545; brush, 80; iron, 31,779.

Piering built, (11 cribs,) 352 running feet; repairs of breaks, 72 running feet.

Amount paid for labor and material.

Timber	$11,059 20
Plank	115 20
Stone, (includes putting in)	8,087 40
Brush	240 00
Iron	3,864 82
Dredging	36,085 27
Framing	2,038 50
Sink-pieces	6,568 73
Total	68,059 12

A 17.

GRAND HAVEN, MICHIGAN.

Grand Haven is on the east shore of Lake Michigan, directly east from Milwaukee. It is the port of entry for the district of Michigan, embracing all the harbors on the east shore.

The revenue collected during past year amounted to $13.506 05.

Grand Haven has a light-house with light of fourth order, a pier-light, range-lights, and a fog-bell. The improvement of this harbor is of great importance, and the benefits to commerce and navigation will be both general and local. It is the outlet for the country bordering on Grand river along which foundries, mills, and factories of all kinds are being built, indicating that the trade is not only on the increase, but is to be permanent.

It is the terminus of the Detroit and Milwaukee railroad, and the success of this line of communication between the east and west depends upon the condition of the harbor. During stormy weather Grand Haven is eagerly sought for by vessels on account of its easy access and complete protection. The plans proposed for improving this

harbor were as follows: To extend south pier 600 feet; to build a north pier—giving channel a width of 200 feet; to close-pile the bend in the river. The appropriation, $105,000, will be sufficient to complete as much of south pier as it is thought necessary to build at present.

A north pier is needed and will cost $200,000. Seventy-five thousand dollars can be used during the coming year. A breach is being made in old pile-pier near the shore line. There will probably be enough money left to repair this after completing crib-work. An estimate for cost of this improvement is added.

Pier-work was commenced in June, 1867. During last season six cribs (32 feet each) were placed. This season two cribs (50 feet each) have been sunk, and two more of same dimensions will be put in a few days. The superstructure has been put on last year's cribs and looks very well. In putting it on the cribs were so irregular it was necessary to drive some piles. The close-piling in bend of river was commenced last July, and finished (except part of filling) in November. Nineteen hundred and forty-three feet have been driven. A short time after the work was completed the schooner Hungarian ran into it, and did considerable damage. It was repaired, but gave way again when used a few months since, as a receptacle for large quantities of gypsum. The parties interested intend making the necessary repairs. In filling the close-piling with slabs a portion of them were so placed that they will not settle to the bottom, no matter how much stone is put on them. This allows the current to run through, and it may in time undermine some of the piles, although most of them are driven in deep water. The work done on the old railroad pier by Captain Heber Squier is as solid as when first built. The fender piles, a part of the original plan, have been omitted as unnecessary. The end of this work, under the light, has been filled in with slabs and stones.

In addition to above work, 269 old piles in river have been pulled out during the year. This work was attended with some difficulty, as the piles were firmly imbedded in the clay.

There has been some difficulty in settling up with Mr. R. A. Conolly for work done last year. Through mistakes in measurement he was overpaid. When the mistake was discovered it was found to be a very difficult task to correct it. The material in work was correctly measured, but more material had been delivered and accepted than had been used in work. Only a portion of the material could be found, although Mr. Conolly proved conclusively that he had delivered the amount claimed.

The amounts paid for originally are as follows: Timber, 13,519 cubic feet; piles, 71,118 cubic feet; stone, 701 cords; brush, 2,263 cords; iron, 52,235 pounds; framing, 15,020 lineal feet; piles driven, 1,804.

The error in timber and framing arose from estimating timber by lineal feet, instead of cubic feet. The amounts for which Mr. Conolly should have been paid are as follows: Timber, 8,104 cubic feet; piles, 67,774 cubic feet; stone, 701 cords; brush, 2,263 cords; iron, 52,235 pounds; framing, 9,440 cubic feet; piles driven, 1,555.

The differences between above amounts are to be returned by Mr. Conolly. They will be as follows:

Timber, 5,415 feet, at 24 cents per cubic foot	$1,299 60
Piles, 1,344 feet, at 10 cents per lineal foot	134 40
Framing, 5,580 feet, at 9 cents per cubic foot	502 20
Driving piles, 249 feet, at $1 75 each	435 75
Total	2,371 95

To offset this, Mr. Conolly has claims against the government for pulling 269 piles, at $4 50 each, $1,310 50; repairs on close-piling, $900. The first claim is perfectly just and has been allowed, leaving a balance due from Mr. Conolly of $1,061 45. The second claim for the repairs is entirely too large, and cannot be settled until a bill is presented showing material used and labor performed. The following material is still unaccounted for: Piles, 23,124 lineal feet; iron, 11,716 pounds. Of these amounts, all that is left is 4,800 feet of piling, left between piling and shore.

The stone was also short 43 cords; this amount has been delivered this year. Other small amounts are unaccounted for, but the exact number of cords cannot be ascertained.

The discovery of the disappearance of government material naturally excited suspicion, and an investigation into the case disclosed the fact that certain parties had been stealing from the government on a grand scale.

During the past season, owing to the number of harbors under my charge, it was impossible to be present at all the points when stone and other material was being delivered. I had no means of measuring the stone accurately, as it was scattered along the dock in irregular piles, and often unloaded directly into the cribs; consequently I was obliged to depend upon the weekly reports of the foreman, who, being constantly on the ground, should have been able to detect any attempt on the part of the contractors or their agents to defraud the United States. The reports of the foremen at the harbors of Grand Haven and Muskegon having given much trouble last year, it was determined at the opening of present season to appoint new men to take immediate charge of these harbors. Captain John F. Sanders, known from his former services to be well fitted for the position, was appointed to superintend both harbors. When appointed he was ordered to examine into all the work done previous to taking charge. He discovered the following facts: that his predecessors had taken in all cases the bills of lading as evidences of the quantity of stone delivered; that they had been deceived by these bills, the cargoes for which they had receipted being at times enough to sink the vessels to the bottom of the lake; that captains of vessels had admitted that they commenced discharging their cargoes when they left Chicago, and when they reached Grand Haven they had not more than one-third of their cargo on board. Captain Sanders's investigations, and certain disclosures, brought to light the fact, that not only had the government been defrauded by bills of lading, but that property received and paid for had been used and sold by certain parties in Grand Haven and Muskegon. He found stone scattered through Grand Haven similar to that furnished for cribs. Inquiry showed that said stone had been sold to parties by Mr. P. A. Woolly, foreman for Mr. Conolly on his contract work at Grand Haven. Investigation showed the stone had been paid for by the United States and stolen by Mr. Woolly. These facts were reported immediately to the United States district attorney for the western district of Michigan, and he was requested to examine into all the work on the east shore, to unearth all swindling, and cause the arrest of every party in any way concerned.

At Grand Haven, Mr. Woolly is the only man against whom there is any evidence at present. He was arrested upon the charge of stealing stone, and subsequently the charge of stealing iron was added. The iron charge is a very plain one, as it was sold by him after pointing it out as government material. Since his arrest I have discovered conclusive

evidence of his selling government piles; the same has been forwarded through Captain Sanders to the district attorney.

When arrested, Mr. Woolly stated that Messrs. Ledlie and Corse, Messrs. Squier and White, and Mr. Conolly had defrauded the government to an enormous extent, but he has not furnished, nor have we been able to obtain from other sources, any proof that there is guilt on the part of any one but himself. When his trial takes place, all the facts in the case will be brought to light. At Muskegon, Messrs. Brown & Co. used a quantity of stone and 1,100 cubic feet of timber. Mr. Stephanson also used some stone. These parties claimed they had permission from the foreman to take the material, and Captain Sanders reports it has all been returned. Messrs. Jones & Co. took some stone without permission, and, probably, without the intention of returning it. The district attorney is acquainted with the facts in the case. A certain John Gregory was arrested for stealing stone; he was brought before the United States court, reprimanded, and discharged, on account of his extreme youth, (age unknown.) There may be other cases both at Grand Haven and Muskegon, but they are not yet discovered. Upon the slightest intimation of fraud on the part of any one connected with the harbor work, the district attorney has been notified and requested to examine the case thoroughly.

I am, very respectfully, your obedient servant,

A. MACKENZIE,
Captain United States Engineers.

Brevet Colonel J. B. WHEELER,
Major of Engineers U. S. Army.

Estimated cost of repairing pier between fog-bell and pier-light—length 490 feet.

50 oak piles, 40 feet long, at 11 cents per foot	$220 00
Driving 50 piles, at $1 50 each	75 00
Redriving 191 piles, at $1 50 each	286 50
Taking down 2,680 running feet of whaling, at 10 cents	268 00
Taking down 1,338 running feet of ties, at 10 cents	133 80
Putting on 980 running feet of whaling, at 12 cents	117 60
Putting on 1,118 running feet of cross-ties, at 12 cents	134 16
250 cords of stone, at $12	3,000 00
380 cords of slabs, at $1 50	570 00
Total	4,805 06
Add 20 per cent. for contingencies	961 01
	5,766 07

Abstract of contract for improving harbor of Grand Haven, Michig (crib-work.)

Contractor.	Nature of contract.	Pric
James H. Ledlie	12-inch timber, per lineal foot	$0
Do	3-inch plank, per M, (board measure)	25
Do	Piles, pine, per lineal foot	
Do	Piles, oak, per lineal foot	
Do	Stone, per cord of 128 cubic feet	16
Do	Brush, per cord of 128 cubic feet	2
Do	Iron bolts, per pound	
Do	Iron spikes, per pound	
Do	Framing, per lineal foot of timber	
Do	Driving piles, per lineal foot	

Abstract of contract for improving Grand Haven harbor, (close-piling

Contractor.	Nature of contract.	Pric
R. A. Conolly	12-inch timber, per lineal foot	$0
Do	Piles, pine, per lineal foot	
Do	Stone, per cord of 128 cubic feet	18
Do	Brush, per cord of 128 cubic feet	1
Do	Iron bolts and spikes, per pound	
Do	Driving piles, each	1
Do	Framing, per cubic foot	

Abstract of materials received and used, and labor performed, at harbor of Grand Haven, Mi gan, from June 30, 1867, to June 30, 1868.

Contractor.	Timber.	Plank.	Piles.	Stone.	Brush.	Iron.	Framing.	Cribs placed.	
James H. Ledlie	32,682	11,088	930	889	71	43,672	26,987	10	
R. A. Conolly	8,104	.....	69,774	701	2,263	52,235	9,440	.....	1
Total	40,786	11,088	70,704	1,590	2,334	95,907	36,427	10	1

Material used.

Contractor.	Timber.	Piles.	Stone.	Brush.	Iron
J. H. Ledlie	27,947	930	889	71	36,
R. A. Conolly	8,104	46,650	701	2,263	48,
Total	36,051	47,580	1,590	2,334	84,

Length of pier built, 292 lineal feet; length of close-piling built, 1,
lineal feet.

Abstract of amounts paid out for material and labor at harbor of Grand Haven, Michigan, from June 30, 1867, to June 30, 1868.

Material.	Amount paid to Conolly.	Amount paid to Ledlie.	Total.
Timber	$1,944 96	$7,190 04	$9,135 00
Plank			
Piles	6,977 40	550 80	7,528 20
Stone	13,143 75	15,059 66	28,203 41
Brush	3,281 35	156 20	3,437 55
Iron	4,701 75	3,930 48	8,631 63
Dredging			
Framing	849 60	2 968 57	3,818 17
Driving piles	2,721 25	69 75	2,791 00
Total	33,619 46	29,925 50	63,544 96

A 18.

MUSKEGON, MICHIGAN.

The city of Muskegon is on Muskegon lake, six miles from the harbor and entrance from lake Michigan. It is in the collection district of Michigan, and the nearest port of entry is Grand Haven, 13 miles from mouth of Muskegon lake. The amount of revenue collected for last fiscal year was $3,242 50.

The nearest light-house is at mouth of harbor; it is small, with light of sixth order. The number of vessels arriving and departing during past year amounted to 4,560. The exports are almost entirely lumber, and the imports general merchandise. Both the local and general interests are benefited by keeping this harbor in good condition.

Muskegon is one of the largest if not the largest lumber market (primary) in the world. It possesses the same advantages as a harbor of refuge as the other points on the shore. The plan for improving this harbor was given in last year's report, as follows:

To extend south pier on a line with inner face of old slab pier; to build a north pier in extension of present north pier and parallel to south pier. 700 feet of piering extended the piers into 17 feet of water, and crossed all the bars. The estimated cost was $58,450. $59,000 was appropriated, and will be sufficient to do all the work at present contemplated.

Work was commenced in July, 1867, and during last season six cribs were placed on south side, and two on north side. A triangular crib was placed in angle between new and old work, but the violent seas broke it to pieces last fall; a part of the superstructure on south side was built. The cribs stood very well during winter, with exception of outer crib on south side, the northwestern corner of which settled badly. The cribs on north side settled under water, but remained level. This season four cribs have been placed, and the superstructure almost completed. The breach between old and new south pier has been closed by a pile structure; it will stand well.

There is at present 12 feet of water in channel, and 13 feet on the outer bar.

I am, very respectfully, your obedient servant.

A. MACKENZIE,
Captain United States Engineers.

Brevet Colonel J. B. WHEELER, U. S. A.,
Major of Engineers.

Abstract of contracts for improving harbor of Muskegon, Michigan.

Contractors.	Nature of contract.	Price.
Galen Eastman	Twelve-inch timber, per M, (board measure)	$12 83
Galen Eastman	Three-inch plank, per M, (board measure)	14 00
Galen Eastman	Piles, per lineal foot	08
Ledlie & Corse	Stone, per cord of 128 cubic feet	13 88
Ledlie & Corse	Brush, per cord of 128 cubic feet	2 00
R. Nelson Gere	Iron bolts, per pound	04.9
R. Nelson Gere	Iron spikes, per pound	04.9
Heber Squier	Framing, per lineal feet of timber	12

Abstract of material received, used, and labor performed, at Muskegon, from June 30, 1867, to June 30, 1868.

Material received and labor performed: Timber, 496,123; stone, 1,358; iron, 69,161; framing, 25,116; cribs placed, 12.

Material used: Timber, 301,392; stone, 706; iron, 23,167.

Length of pier built: 384 lineal feet, (12 cribs.)

Amounts paid out for material and labor.

Material.	Am't. paid.	Am't. due.	Total.
Timber	$6,365 25	.....	$6,365 25
Piles	.....	.....	.....
Stone	18,849 04	.....	18,849 04
Brush	.....	.....	.....
Iron	1,135 18	$2,253 70	3,388 88
Framing	2,756 64	257 28	3,013 92
Total	.....	.....	31,617 09

A 19.

WHITE RIVER, MICHIGAN.

White river, or White lake, is 25 miles north of Grand Haven. It is in the collection district of Michigan, and the nearest port of entry is at Grand Haven; the nearest light-house is at Muskegon, 12 miles south. No collections were made up to April 15, 1868; since that time a deputy collector has been stationed at Whitehall, and has collected $136 85.

The number of vessels arriving and departing for year was 2,234. The imports amounted in value to $525,000; and the exports to $1,150,000. The benefits to commerce and navigation will be both general and local.

The following is the plan that was adopted for improving this harbor: To make a new cut from White lake into lake Michigan, and by this means avoid the long and narrow channel connecting the lakes. The cut was to be 200 feet wide, and its sides close-piled; piers were to be extended into lake Michigan. The work was commenced in July, 1867. Last season 75,000 cubic yards were taken out, leaving a narrow strip between the two lakes. The communication was made about May 1, 1868, and the current soon washed out a four foot channel. Dredging was stopped June 6, 1868, all the money that could be used for that purpose being exhausted. The cut is almost completed and close piled. There

is nine or ten feet of water in channel, between piers, and a bar outside is the only obstruction; vessels drawing five and a half feet of water can enter with ease. This is a greater depth of water than they have ever had in the old channel. The cost of work, as shown by previous estimates, will be $170,530 80. This amount will be sufficient to complete work; $75,000 will be required during next fiscal year. Until a sufficient amount is appropriated to complete outside piers, this harbor will be of but little service.

When they are built it will make one of the best, if not the best harbor, on the shore. To render efficient and preserve what has already been done, the work must be completed according to proposed plans.

I am, very respectfully, your obedient servant,

A. MACKENZIE,
Captain Engineers U. S. Army.

Brevet Colonel J. B. WHEELER, U. S. A.,
Major of Engineers.

Abstract of contracts for improving White River harbor, Michigan.

Contractors.	Nature of contracts.	Price.
Thomas S. White	Twelve-inch timber, per lineal foot	$1 41
Thomas S. White	Three-inch plank, per M, (board measure)	14 50
Thomas S. White	Piles, per lineal foot	07
Carkin & Kimball	Stone, per cord of 128 cubic feet	14 90
Carkin & Kimball	Brush, per cord of 128 cubic feet	1 42
R. N. Gere	Iron bolts, per pound	04.9
R. N. Gere	Iron spikes, per pound	04.9
Carkin & Kimball	Framing, per lineal foot of timber	07
Carkin & Kimball	Driving piles, per lineal foot	05¼
Fox & Howard	Dredging, per cubic yard	28

Abstract of material received, used, and labor performed, at White river, Michigan, from June 30, 1867, to June 30, 1868.

Material received and labor performed: Timber, lineal feet, 15,574; plank, board measure, 1,620; piles, lineal feet, 36,690; iron, pounds, 20,772; dredging, cubic yards, 105,377; framing, lineal feet, 4,506; piles driven, lineal feet, 30,630.

Material used: Timber, 11,068; piles, 6,060; iron, 11,000.

Close piling built, 1,000 feet.

Amounts paid for material and labor.

Material.	Amounts paid.	Amounts due.	Total.
Timber	$2,195 93		$2,195 93
Plank	23 49		23 49
Piles	2,568 30		2,568 30
Iron	1,017 82		1,017 82
Dredging	29,505 56		29,505 56
Framing	177 52	$137 90	315 42
Driving piles	1,072 50	612 15	1,684 65
Total			37,311 17

A 20.

PENTWATER, MICHIGAN.

Pentwater, on the east shore of Lake Michigan, is 12 miles south of Père Marquette, and eight miles north of Petit Point au Sable, the most westerly point of the southern peninsula of Michigan. It is in the collection district of Michigan, and the nearest port of entry is at Grand Haven. The nearest light-house is at Grand Point au Sable, 20 miles north. A deputy collector has been stationed at this point since April 15, 1868, and the amount of revenue collected since that time amounts to $136 85. The number of arrivals and departures of vessels for the year ending July 30, 1868, is 2,234. The exports for the year, consisting of lumber, shingles, staves, ship timber, fish, &c., amounted in value to about $900,000. The imports for same time are estimated at $800,500 and consisted of general merchandise. The benefits to commerce and navigation from this improvement will be both general and local. The village of Pentwater is improving rapidly, and its shipping interests and trade are on the increase. Like Père Marquette, it is located between Grand and Petit Points au Sable, and will give shelter to many vessels when storms prevent them from rounding either point.

The plans for improving this harbor were given and discussed in the report of last year. They were: to throw aside the old slab piers, to widen the channel to 150 feet, to close-pile the sides of cut, to extend piers across the outer bar a distance of 1,280 feet, to dredge the whole channel to a depth of 12 feet. The direction of piers was to be N. 70 W. (magnetic.) This plan was slightly modified when work was commenced; the south pier was commenced at end of old slab pier, leaving a strip of slab-work 30 feet wide to be removed. It was found impossible to give the channel a width of 200 feet without great expense. The estimated cost of work was $327,713 40. This amount is sufficient to complete the work as proposed; $50,000 can be used during the next fiscal year. Work was commenced the latter part of July, 1867. Six cribs were placed during last season. The cribs were built at Père Marquette and towed to Pentwater, this caused great delay, and the contractors failed to complete the amount of work required last year. The cribs placed were poorly put in, and present a very uneven foundation for the superstructure; the outer crib settled four feet under water. Four cribs have been put in this year, making 10 cribs (320 feet) in all on the south side. The foreman reports that the last cribs are well placed and are settling evenly. The superstructure has been commenced on the cribs put in last season, and improves their appearance. In addition to the pier-work, dredging has been done to the amount of 15,944 cubic yards. The people of Pentwater have expended several thousand dollars in filling the bridge pier on north side with slabs. The old boiler of propeller Mary Stuart has been removed from channel. A brake was made in bridge pier by the ice; this has been repaired by M. C. Mears, proprietor of the pier. Mr. F. Rutzel, foreman of works at Pentwater, recommends placing one or two cribs at end of north pier to protect it. The permanency of this work depends, as at other points, upon the time the superstructure will last and the rate at which the shore-line follows out the piers.

I am, very respectfully, your obedient servant,

A. MACKENZIE,
Captain United States Engineers.

Colonel J. B. WHEELER,
Major of Engineers U. S. Army.

Abstract of contract for improving Pentwater harbor, Michigan.

Contractors.	Nature of contract.	Prices.
P. M. Danaher	12-inch timber, per lineal foot	$0 12
Do	3-inch plank, per M, (board measure)	12 00
Do	Piles, per lineal foot	08
P. D. Van Wagner	Stone, per cord of 128 cubic feet	16 00
Do	Brush, per cord of 128 cubic feet	6 00
R. Nelson Gere	Iron bolts, per pound	04.9
Do	Iron spikes, per pound	04.9
Hasbrouck & Couro	Framing, per lineal foot, (timber)	14
	Dredging, per cubic yard	36

Abstract of material received, used, and labor performed, at Pentwater, Michigan, from June 30, 1867, to June 30, 1868.

Material received and labor performed: Timber, 41,666; plank, 7,000; stone, 967; iron, 69,059; dredging, 15,944; framing, 20,470; cribs placed, 10.

Material used: Timber, 20,470; stone, 550; iron, 23,025.

Length of pier built, 320 lineal feet, (10 cribs.)

Materials paid for.	Amount paid.	Amount due.	Total.
Timber	$5,000 00		$5,000 00
Plank	84 00		84 00
Stone	15,472 00		15,472 00
Iron	1,439 13	$1,944 76	3,383 89
Dredging	5,739 84		5,739 84
Framing	1,852 80	1,013 04	2,865 84
Total			32,505 57

A 21.

PÈRE MARQUETTE, MICHIGAN.

Père Marquette, or Luddington, as it is now called, is on the east shore of Lake Michigan, 30 miles south of Manistee. It is in the collection district of Michigan, and the nearest port of entry is at Grand Haven. The nearest light-house is at Grand Point au Sable, eight miles to the north.

The plans adopted for the improvement of this harbor were to build a south pier, commencing at point 20 feet south of present slab pier, and extending into Lake Michigan 640 feet; to build a north pier in extension of present pier 450 feet long; to remove old slab pier on south side, and to cut down slab-work on north side, replacing it by timber superstructure. The direction of piers was to be three degrees north of west, and the channel was to be 200 feet wide after the old slab-work was removed.

For the improvement of this harbor it was estimated $270,682 would be required. Seventy-five thousand dollars was asked for last year; a portion of this amount could now be used as the present appropriation; $50,000 is almost expended. The same amount can be used during the next fiscal year.

Work was commenced last June, (1867.) The contractors expected to complete the entire work last season, but failed in the attempt. Nineteen cribs were placed; 17 on south side and two on the north side, but no superstructures were built. Dredging was commenced this year, and 8,900 yards have been removed. A crib 25 feet square is almost completed; it will probably be finished and placed at end of present south pier.

The work remains as it was at close of last season; the cribs have settled very unevenly, and the line is not good. The three outer cribs are some distance under water, the last one being nine feet below surface. Three courses were torn off these cribs by a vessel.

The channel has been greatly improved by the work already done; there is now from 8.5 to 9.5 feet of water. The benefits to commerce and navigation will be more general than local in their character. Luddington is as yet but a small place, with but little trade. As a harbor of refuge it will be of importance, being in the bay between Grand and Petit Points au Sable. It does not admit of permanent completion as at other points; the plans adopted require wooden piers, the superstructure of which must be replaced every few years. The piers will require extension in time. Annexed you will find abstract of contractors and prices paid for material, and abstract of materials received and used. Unless another appropriation is made this harbor, will be left in an unfinished condition. No superstructure can be built on the cribs already placed, although the timber is on hand for the purpose.

I am, very respectfully, your obedient servant,

A. MACKENZIE,
Captain United States Engineers.

Brevet Colonel J. B. WHEELER,
Major of Engineers U. S. Army.

Abstract of contract for improving Père Marquette harbor.

Contractors.	Nature of contract.	Price.
P. M. Danaher	12 foot timber, per lineal foot	$0 12½
P. M. Danaher	3 foot plank, per M, (board measure)	18 00
P. M. Danaher	Piles, per lineal foot	08
Ledlie & Corse	Stone, per cord of 128 cubic feet	13 98
Ledlie & Corse	Brush, per cord of 128 cubic feet	1 49
R. Nelson Gere	Iron bolts, per pound	04.9
R. Nelson Gere	Iron spikes, per pound	04.9
Hasbrouck & Couro	Framing, per lineal foot of timber	14
Hasbrouck & Couro	Dredging, per cubic yard	36

Abstract of material received, used, and labor performed, at Père Marquette, Michigan, from June 30, 1867, to June 30, 1868.

Material received and labor performed: Timber, lineal feet, 67,679; plank, board measure, 7,000; stone, cords, 1,483; brush, cords 40; iron, pounds, 68,786; dredging, cubic yards, 8,900; framing, lineal feet, 52,320; cribs placed 19.

Material used: Timber, 52,320; stone, 1,483; brush, 40; iron, 68,786. Length of pier built, 608 feet, (19 cribs.)

Amounts paid out for materials and labor.

Material.	Amounts paid.	Amounts due.	Total.
Timber	$2,862 12		$3,462 12
Plank	126 00		126 00
Stone	20,732 34		20,732 34
Brush		$59 60	59 60
Iron	3,370 51		3,370 51
Dredging	2,988 00		2,988 00
Framing	7,324 80		7,324 80
Total			43,063 37

A 22.

MANISTEE, MICHIGAN.

Manistee is situated on the east shore of Lake Michigan, in latitude 44° 20′ north. It is in the collection district of Michigan, and the nearest port of entry is at Grand Haven. The nearest light-house is at Grand Point au Sable, 18 miles south, and consists of a tower 100 feet high, with lens of third order, showing a fixed white light. It was lighted for the first time November 1, 1867. A light-house is to be built at Manistee as soon as title to point selected is obtained. The amount of revenue collected for the year ending June 30, 1868, was: Internal revenue $8,000; customs $1,293; making a total of $9,293. The number of vessels arriving and departing for the same time was 2,016.

The imports for the year amount to $900,000, and consist of merchandise, agricultural instruments, and machinery. The exports amounted, in value, to $1,320,000, and consisted of lumber, &c. The benefits arising from the improvement of this harbor will be both general and local.

A daily line of fine propellers run from Manistee to Milwaukee, and other steamboats and sailing vessels connect Manistee with points along east shore. These vessels carry large numbers of passengers and great quantities of freight. All vessels going or coming around the lakes run near to Manistee, and would at times find it a convenient harbor of refuge.

The plans proposed for improving this harbor are as follows: To extend the south pier in its present direction 960 feet, (30 cribs;) to commence north pier at point opposite present extremity of south pier, and run it to the 12-foot curve, a distance of 960 feet, (30 cribs;) to cut off the point inside south pier and widen the channel; to cut down all the old slab piers to the surface of the water, and build a timber superstructure.

For the completion of the work it was estimated $180,949 would be required; $60,000 was appropriated, and $60,000 was asked for in the last report. This amount was not appropriated, and the work has progressed more slowly in consequence. The same amount can be used during the next year.

Work was commenced July 1, 1867, but no cribs were placed until the middle of August. Fourteen cribs were placed last year; 10 on north side of channel and four on the south side. Since the opening of navigation this year no cribs have been placed, owing to the delay in delivering timber. The superstructure of cribs on north side has been completed and the cribs filled up with stone. Mr. Starke, the contractor for

framing the work, has been anxious to commence the work this year, and, had the timber been delivered, would have completed as much of the south pier as it is contemplated can be built with the present appropriation. Eight cribs can probably be built and placed on south side, making this pier 384 feet (12 cribs) long. In addition to pier work, 18,996 cubic yards have been dredged, removing the bar, between the piers at the mouth, which was formed by the opening left in north pier last year. There are still several bars in the river, some distance above mouth, that give the propellers much trouble, and often detain them for hours. The crib work is well built; the cribs are level and in line.

A serious obstruction to the navigation of Manistee river is a dock and boom for logs; this occupies half the width of the river and the deepest water; it should be removed. As at other points, this harbor cannot be said to admit of permanent completion. If the proposed plans are carried out the channel will be good for many years; but in time the piers must be extended to cut the bars that will form at the mouth. Manistee river has the strongest current, at certain seasons of the year, of any on the shore, and will prevent the formation of bars for a long time. All the work to be done at this harbor, with present appropriation, will be completed within six weeks.

I am, very respectfully, your obedient servant,

A. MACKENZIE,
Captain United States Engineers.

Brevet Colonel J. B. WHEELER,
Major of Engineers U. S. Army.

Abstract of contract for improving Manistee harbor.

Contractors.	Nature of contract.	Price.
Gelly & Weston	12 foot timber, per M, (board measure)	$12 90
Gelly & Weston	3 foot plank per M, (board measure)	14 00
Gelly & Weston	Piles per lineal foot	08
Galen Eastman	Stone, per cord of 128 cubic yards	14 88
Galen Eastman	Brush, per cord of 128 cubic yards	2 00
R. Nelson Gere	Iron bolts, per pound	04.9
R. Nelson Gere	Iron spikes, per pound	04.9
Henry Starke	Framing, per lineal foot of timber	15

Abstract of material received, used, and labor performed at Manistee, Michigan, from June 30, 1867, to June 30, 1868.

Material received and labor performed: Timber, 37,252; stone, 898; brush, 318; iron, 51,353; dredging, 18,326; framing, 25,560; cribs placed, 14.

Material used: Timber, 25,560; stone, 898; brush, 318; iron, 33,027.

Length of north pier built, 320 feet, (10 cribs;) length of south pier built, 128 feet, (4 cribs;) total, 448 feet, (12 cribs.)

Amounts paid out for material and labor.

Material.	Amounts paid.	Amounts due.	Total.
Timber	$5,766 60		$5,766 60
Stone	13,362 24		13,362 24
Brush	636 00		636 00
Iron	1,618 32	$897 97	2,516 29
Dredging	6,458 60		6,458 60
Framing	3,807 45	26 55	3,834 00
Total			32,573 73

A 23.

AUX BEC SCIES, MICHIGAN.

Aux Bec Scies, on Frankfort harbor, is on the east shore of Lake Michigan, near the Manitou islands, and not far from the northern extremity or foot of the lake. It is 30 miles north of Manistee, and 226 miles from Milwaukee, Wisconsin. It is in the collection district of Michigan, and the nearest port of entry is at Grand Haven, 100 miles south. The nearest light-house is at Point Aux Bec Scies, or Point Betsey, as it is known on the lakes, $4\frac{6}{10}$ miles north.

The light is fixed, varied by flashes, and of the —— order. No revenue was collected here during the past year, and no record was kept of the arrivals and departures of vessels. The imports, consisting of general merchandise, amounted in value to $125,000, and the exports, cord wood, fish, &c., to $1,250.

The benefits to commerce and navigation arising from the improvement of this harbor, will be general for some time to come. The country back of Frankfort is good, and is being settled quite rapidly; but the local trade at present amounts to but little. As a harbor of refuge it will be of importance.

The plans for the improvement of this harbor are to make a through cut from Frankfort lake to Lake Michigan; close-pile the sides of cut, requiring 525 feet of piling, and build 1,504 feet of piering (47 cribs) 21 on the north side, and 26 on the south side. The amount required for the entire work, as shown in last report, was $146,000, requiring an additional appropriation of $47,859. This amount will be required the present season, if the work is completed according to proposed plans. The work was not commenced until July 1, 1867, although the contractors were getting out material the previous winter and spring. Up to close of navigation last year the following work was done: The cut between the two lakes was made, in doing which 76,153 cubic yards were dredged; the close-piling on south side was completed, except filling; three cribs were placed on south side. During the winter, cribs were built on the ice. Since the opening of navigation nine cribs have been placed on south side, and the superstructure of eight cribs completed; the north side of cut has been close-piled, and 44,390 cubic yards dredged. The 12 cribs placed are well filled with stone. It has been decided to extend the south pier to 12 feet of water before commencing north pier. When this is done but little money will be left, and not more than two or three cribs can be placed on north side.

There is now nine feet of water in the channel; this will be reduced at times by hard blows from the northwest, but the current will wash

out the sand again, and keep open at most times a good channel. For the permanent protection of the channel the north pier is necessary. The work is well done, and presents the best appearance of any on the east shore. The amount of dredging done greatly exceeds estimate. Owing to the very exposed position of Frankfort, before building the south pier, every blow filled up the mouth of cut, and dredging over the same ground that had been previously dredged was frequently necessary. This was done to obtain a channel through which cribs could be floated to their place. This harbor admits of as permanent completion as any on the east shore. There will be no wash of sand from Frankfort lake, and all that gets into channel must come from outside. As at other points, the shores of Lake Michigan will probably follow out along the piers, and at some future time require more piering to be built. All the work to be done at this harbor, with present appropriation, will be completed within a month.

Messrs. Whitwood & Hubbell will probably wish to close out their contract, and move away all their dredges, scows, tools, &c.

The work is left in good condition, and will stand until another appropriation is made and the work completed.

I am, very respectfully, your obedient servant,

A. MACKENZIE,
Captain U. S. Engineers.

Brevet Colonel J. B. WHEELER,
Major of Engineers U. S. Army.

Abstract of contract for improving harbor Aux Bec Scies, Michigan.

Contractors.	Nature of contract.	Price.
Whitwood & Hubbell....	12-inch timber, per lineal foot	$0 18
Whitwood & Hubbell....	3-inch plank, per M, (board measure)	20 00
Whitwood & Hubbell....	Piles, 30 feet long, oak, each	5 75
Whitwood & Hubbell....	Piles, 30 feet long, elm, each	2 75
Whitwood & Hubbell....	Stone, per cord of 128 cubic feet	17 00
Whitwood & Hubbell....	Brush, per cord of 128 cubic feet	4 50
Whitwood & Hubbell....	Slabs, per cord of 128 cubic feet	2 50
Whitwood & Hubbell....	Wrought-iron bolts, 1⅛ inch square, per pound	06
Whitwood & Hubbell....	Wrought-iron spikes, per pound	07½
Whitwood & Hubbell....	Driving piles, each	6 00
Whitwood & Hubbell....	Framing and building cribs, each	168 00
Whitwood & Hubbell....	Placing, sinking, and filling cribs, each	30 00
Whitwood & Hubbell....	Dredging in common earth, sand, or soft clay, per cubic yard	35
Whitwood & Hubbell....	Dredging in hard clay or hard-pan, per cubic yard	70

Abstract of material received, used, and labor performed, at Frankfort, from June 30, 1867, to June 30, 1868.

Material received and labor performed: Timber, 54,117; piles, 634; stone, 662; brush, 508; iron, 122,441; dredging, 117,573; piles driven, 527; cribs placed, 12.

Material used: Timber, 28,944; piles, 527; stone, 662; brush, 508; iron, 52,600.

Length of pier built, 384 lineal feet; length of close-piling, 525 lineal feet.

Amounts paid out for labor and material.

Material.	Amount paid.	Amount due.	Total.
Timber	$9,741 06		$9,741 06
Piles	3,645 50		3,645 50
Stone	2,261 00	$8,993 00	11,254 00
Brush	1,622 25	663 75	2,286 00
Iron	7,346 46		7,346 46
Dredging	35,508 55	5,642 00	41,150 55
Driving piles	3,162 00		
Building cribs	336 00	1,680 00	2,016 00
Placing		360 00	360 00
Total			77,809 57

A 24.

PÈRE MARQUETTE HARBOR,
June 30, 1868.

COLONEL: In compliance with your orders of the 22d ultimo, I have the honor to present you a report of the amount of work performed in the field and office since the 30th June, 1867, to June 30, 1868.

On the 3d of July, 1867, I received orders from you to organize a surveying party, and proceeded on the 5th to Saugatuck harbor, situated at the mouth of Kalamazoo river, to make a survey of that place with a view of ascertaining the feasibility of improving the same. This survey was completed on the 13th of July, and on the following day I reported to you in Milwaukee, Wisconsin, for further orders.

The computations and plotting was done at the office in July, and the maps projected in pencil on a scale of 1 inch to 200 feet, from which a tracing was made to accompany your report of 1867.

On the 29th of July, 1867, Assistant W. H. Hearding organized a party and proceeded to Frankfort, Michigan, situated at the mouth of Riviere aux Becs Scies, for the purpose of ascertaining the changes made since the improvement on the harbor had commenced, and also ascertain whether the plans adopted required any alterations or not.

Assistant Hearding completed his survey on the 8th of August, and reported to Milwaukee immediately.

Assistant Hearding, on his return to the office, computed and plotted his field notes on a scale of 200 feet to 1 inch in pencil, and a tracing of it was made to accompany your last year's report.

On the 15th of August I received instructions from you to prepare a report and tracings of last year's surveys and have the same ready for your annual report. Accordingly I occupied the time from August 20 to September 10 in making this report and preparing the tracings required, which were drawn by the draughtsman.

On the 5th of August I received orders from you to go to Menomonee river, Green Bay, to examine the work of Mr. J. W. Judson, who had been engaged in making a survey of the mouth of Menomonee river since May 8, 1867, and close the work as soon as possible. Accordingly I left Milwaukee on the evening of August 5 and returned to the office on the 8th, same month, having inspected and closed the work at that point.

Assistant W. H. Hearding was engaged during the month of August in plotting the work done by Mr. Judson in pencil, to enable the draughtsman to make a tracing of it.

The scale on which this map is drawn is 200 feet to one inch, or $\frac{1}{2400}$.

On the 18th of September, 1867, a surveying party, consisting of one assistant in charge, one rodman, one leadman, and six laborers, was organized for the purpose of making a thorough hydrographical and topographical survey of Milwaukee bay and harbor, commencing at the North Point light-house, three miles north of the entrance to the harbor, and extending to South Point, four miles south of the harbor.

A base line 2,945 feet long was selected and carefully graded. Duplicate measurements were accurately made with wooden rods provided for that purpose. The maximum difference between these measurements was $\frac{1}{80}$ of one inch.

On the 18th November, Captain D. P. Heap, corps of engineers United States army, made a reconnoissance of the harbor of Kenosha, Wisconsin, to ascertain the depth of water between the piers and outside of them. A sketch of this reconnoissance was drawn in this office, which shows the changes that have taken place since last surveyed, also the nature of the improvement made during the season.

Assistant Hearding made a similar reconnoissance on the 21st of November, at Manitowoc harbor, and furnished a sketch of the same, which is now on file at this office.

All the above-described work completed the field operations for the season of 1867, and the computations, plotting, and drawing of maps of these several surveys occupied the winter months, which work was executed in the office.

Early in May, 1868, a reconnoissance was made at the harbor of Milwaukee.

The soundings between the piers and on each side of them, also abreast of them, to the depth of 21 feet, were taken to ascertain the accretions which for nearly two years have been forming abreast of the light-house crib. A detailed map on a scale of 100 feet to one inch was also projected and drawn in May last, to facilitate the improvements at this point.

Office work.—After completing the surveys of Saugatuck and Menomonee, Assistant Hearding and myself made estimates of the cost and plan of improvement for each of the harbors mentioned, also several plans and estimates for erecting a breakwater on Racine reef, the survey of which had been made in May, 1867. All these estimates were given to you in my report of September 10, 1867. The draughtsman, Mr. E. Dumais, was engaged in June and July on projecting the maps of Racine harbor and reef; in August he drew the map of Saugatuck harbor, and was engaged on it until the 10th of September. During the months of October and November a map of Frankfort harbor was drawn on a scale of 200 feet to one inch, and all the details on a scale of 100 feet to one inch. Tracings of each of these maps were also made for office use, and the original put on file.

The month of December was occupied in making the computations of survey of Milwaukee bay and harbor, and preparing sheets of antiquarian paper to plot the same. January, February, March, and April, 1868, were devoted to the finishing of the following maps: Menomonee river; White Lake map, (unfinished last year;) one map of Milwaukee bay, on a scale of 400 feet to one inch, or $\frac{1}{4800}$; one map, details of Milwaukee harbor, scale of 200 feet to one inch, $\frac{1}{2400}$; and a tracing of two of these maps.

The months of May and June were principally devoted to making new plans of cribs and tracings of the same. Four of these new plans were

made; and a map of Milwaukee harbor, survey of May, 1868, was also completed.

There now remains but two more tracings to be made. These are of the two sheets of Milwaukee harbor and bay. Duplicates of all the others have been made to refer to, and thereby preserve the originals.

I am, colonel, very respectfully, your obedient servant,

WM. T. CASGRAIN,
Assistant Engineer, and Superintendent of Surveys.

Brevet Colonel J. B. WHEELER,
Major Corps of Engineers, Milwaukee, Wisconsin.

APPENDIX B.

Annual report upon the several civil works—improvement of harbors and rivers—under the charge of Brevet Major General T. J. Cram, colonel of engineers, for the fiscal year commencing 1st July, 1867, and ending 30th June, 1868.

1.—IMPROVING ST. MARY'S RIVER, MICHIGAN.

At the commencement of this year there was available for this work the sum of $99,995 44; and the work during the year has been, under the contract, confined to dredging the middle channel, Lake George, and it has been the intention to complete this channel thoroughly to the standard fixed for the improvement, before moving the machinery to another place in the river.

From July 1 to November 8, 1867, the close of the season, one "Osgood" dredge worked on 21 days, and two worked on 87 days, for a greater or less number of hours in the day, which, according to my rule for keeping the dredging time, consists of 24 hours. To simplify the results, I reduce the total time for which the dredges actually worked to the number of hours one dredge would have worked continually to produce the same result that both did, and find the equivalent total number of hours' work for the one dredge to have been 2,468½ hours, and the amount dredged, towed away, and dumped, for the same time, 109,724 cubic yards soft clay, highly favorable for dredging.

The operations recommenced 12th May, 1868, with one dredge, and continued with that until 17th of June, when another was added to the force.

To 30th of June, the end of the fiscal year, the results have been reduced as above to the equivalent performance of one dredge, as follows: total number of hours, 555¼, and the amount of the same kind of soft clay dredged, towed away, and dumped, for the same time, 28,691 cubic yards.

I now aggregate for the whole fiscal year, embracing all the days, except Sundays, on which it was practicable to work, and find the number of hours during which the work was being done 3,024, and the amount removed from the channel 138,415 cubic yards. The measurements were all made in the dumping scow; I could get no bids to measure otherwise, and the contract had to be made with this mode of measurement.

From the above figures we deduce the performance of the dredge to have been 45.78 cubic yards per hour.

The amount expended during the fiscal year for work and contingencies to 30th June, 1868, is $67,942 87, distributed as follows:

To the contractor, including the 10 per centum retained until completion of his contract, (this includes payment for 80 cubic yards dredging in June, 1867)	$66,477 60
To inspectors of dredging, for services	807 00
For mileage of officers to inspect	133 00
Incidental expenses laying out work	44 29
Purchase of boat for inspector's use	50 00
For the proportional part of office expenses chargeable to this work	430 98
Total	67,942 87

All contingencies, including inspector's services, it will be seen from the above are $1,465 27. The contingencies therefore are only $2\frac{2}{10}$ per cent. of the whole expenditure.

The money available at the close of the year is $32,052 57.

From the report of my assistant, Captain G. J. Lydecker, corps of engineers, of the result of his recent inspection, there will be at least 80,000 cubic yards yet to be dredged before we shall have this channel completed. This, added to what has already been dredged under this contract, will swell to complete it to the probable amount of 218,526 cubic yards, which shows an excess of 51,252 cubic yards above what I estimated in my first report upon this channel, August 23, 1866. Whence this excess? That estimate of mine was made upon a survey made in 1864. In that first report it will be seen that I concluded, from the comparison therein drawn, that the unfinished channel left by Captain Whipple, corps of topographical engineers, in 1859, was filling up. This excess is partly due to this filling, since 1864, and partly to the mode of surveying the channel in 1864, which mode, however minute, was illy adapted to the problem of precise calculation of the amount to be dredged. Surveys for this purpose must be made in a more particular manner, or they are not worth much for the engineer of construction.

The money that we have available from the existing appropriations, 1st of July, will not complete this Lake George middle channel by about $15,000. I trust this at least may be appropriated the present session of Congress, if no more, for St. Mary's river.

The amount requisite to be appropriated hereafter to complete all the improvements contemplated in this river is $398,983. This does not include anything for improving St. Mary's canal.

I think after all the improvements, exclusive of the canal, shall be made, the annual amount thereafter required to keep the improvements in order will probably be $10,000.

2.—Improving mouth of Au Sable river, Michigan.

The first appropriation of $50,000 was made for this March 2, 1867. Of this there was available at the commencement of the present fiscal year the whole $50,000. Owing to contention among bidders, arising from different constructions of the law in its specifications for the assignment of contracts, this was not put under contract, or rather the contracts were not approved until 16th December, 1867. Hence nothing in the shape of active work for the piers, except to make preparations for delivering materials, could be done, until the opening of the working

season in 1868. From that opening up to the 30th June, 1868, activity has prevailed at the site, as for example—

We had to make a complete re-survey with soundings referred to the lowest stage of water, and to establish the bench-mark for that stage, in order to locate the piers and find how deep dredging would have to be done.

A considerable amount of materials were delivered in May and June, but no cribs sunk in place up to the close of this fiscal year. Total amount expended during this fiscal year, $4,497 62, as follows:

To contractors for materials delivered	$3,622 68
To inspectors for services, extra tax	127 67
For survey	238 17
Advertising	22 80
For proportional amount office expenses chargeable in turn to this work	486 30
Total	4,497 62

Leaving available after 30th June, 1868, with which to prosecute the work, the sum of $45,502 38.

Besides this, the amount required to complete the work and yet to be appropriated is $20,000.

This ought to be furnished so as to be made available the present season, to perfectly secure the work we shall, I trust, have done before the close of navigation of 1868, and during the winter, before the spring freshets and storms of 1869 shall disturb the work.

This will always be an expensive harbor to keep open, owing to the enormous quantity of sand coming down the river and floating lake-shorewise.

The annual expenditure to keep it in order will not be less than $6,000.

3.—Improving mouth of Saginaw River, Michigan.

For this the amount available at the commencement of this fiscal year was $95,077 35.

The channel, 195 feet in width and 12 feet deep, is being cut by dredging through the hardest material I have ever known excavated without blasting. The dredging was by one dredge working alone duing July; and for the remainder of the working season, which continued until 30th November, two were at work.

From 1st July to 30th November there were excavated, towed away, and dumped, of this very hard material, 54,312 cubic yards, and the time of working was 1,481½ hours.

The dredging was recommenced 7th April, 1868, with one dredge, and to 30th June the amount excavated by this lone machine was 25,492 cubic yards, and the time of working 534½ hours. Aggregating for both seasons, we find the amount of dredging for the fiscal year to have been 79,804 cubic yards, and the time 2,016 hours.

The average work of the dredge per hour, therefore, was $39\frac{6}{10}$ cubic yards during the year for the actual time the machine worked. The amount expended during this year is $66,928 06, as follows:

For work done in June, 1867, not paid for until present fiscal year	$2,706 78
To the contractor	63,045 16
To inspector for services	702 00

Mileage to officers to inspect	$41 80
For obtaining commercial statistics and low-water stage for a bench-mark	65 50
For office expenses chargeable in turn to this work	366 82
Total	66,928 06

It will be perceived that all contingencies, besides paying the contractor, amount to only 1¾ per cent. of the whole expenditure for the year.

The amount available to prosecute the work from 1st July, 1868, is $28,149 29.

In our new channel there have been discovered recently a large boulder rock and an old vessel hulk, which must be removed the present working season, and, if we meet with no further obstacles, it is our intention to have this channel completed by 1st September, 1868. And to make certain of it, I ask for $15,000 more to be assigned to this work out of the general appropriation, to meet the contingency of these unexpected obstructions.

Besides this $15,000, no additional appropriation will be necessary to complete this improvement to the standard of 195 feet width and 12 feet depth.

The commerce is very large here and increasing; as a measure of the advantage of this new straight ship channel through the outer bar, it may be remarked in this place that the expense of lighterage has been estimated by our reliable shippers at not less than $1,000 a day during the whole season of navigation.

From September 1st to 10th December, 1868, there will be 71 days, and if we can have the work completed so as to allow the vessels to pass through by the first date, commerce will be relieved the present season of this tax for lighterage by at least $71,000, and the following season by $244,000, and so on.

From our observations during the process of opening this cut, no evidences have arisen to indicate that it will fill up; on the contrary, the evidence is that it will by the outflow of the river be kept clear. Still, not being positively certain of this, I put down the probable estimate of annual expenditure, to keep it in order, say to the amount of $2,000.

4.—Improvement of St. Clair Flats, Michigan.

Congress, by its act approved March 2, 1867, decided the plan of improvement to be by a new straight ship canal through the shoal.

Owing to a delay in awarding the contracts, arising from differences of construction of the law, the contracts were not approved until about the 20th August, 1867. From that time, during the remainder of the fiscal year to 30th June, 1868, the work has been in active progress. The contractor worked two dredges from 10th September to close of the working season, November 16, 1867, delivered considerable material for the revetment of the banks, and during the winter constructed adequate machinery to a scale commensurate with the magnitude of the work, and recommenced operations of dredging with three excavators and one crane dumper, pile-drivers, &c., and up to 30th June, 1868, an extensive amount of work has been well done.

At the beginning of the fiscal year, July 1, 1867, there was available

work $229,970 32, and during the fiscal year there has been
ed for work and materials and contingencies to 30th June, 1868,
3 08, as follows:

tractors	$13,286 28
ector for services	588 57
vey for location of canal and range signals and lishing range signals	965 33
ising	107 25
d purchase of boat for inspector	117 00
xpenses chargeable to this work	478 65
otal	15,543 08

will be available 1st July, 1868, of the appropriations of 23d June,
d 2d March, 1867, for the future progress of the work, the sum
,427 24.

ork has gone on admirably since we got fairly started. It was
xatious, and expensive process to lay out the work and establish
stablish the range signals, the whole field of the triangulation
ting the canal being a sheet of water without any footing of dry

st accurate system of sounding is kept up, always in advance of
struction, in six lines parallel to the axis of the canal, at distances
the lines of only 10 feet. The soundings are taken, not with a
d line, but with a graduated rod. Among his other duties the
or, with a laborer as his only assistant, takes these soundings,
re returned to the office in sections of every 600 feet of the canal
, and reduced to the plane of reference and plotted. From these
compute the amount of dredging measured in the natural bed,
the contractor accordingly.

lredge cuts a trench in the under-water ground to ease the driving
iles, and it is found for this purpose, for driving the sheet piles,
have to cut to a depth of 10 feet below the surface of the water.
construction of the revetments of the dikes is always kept in
of the dredging for the canal waterway.

rane dumper receives the earth from the dippers of the dredges
its long arm swings its earth holder over the revetment work,
holder is emptied into the canal banks, of course all the machinery
orked by steam power.

progress of construction the labor of dredging for the waterway
onstruction of the revetments or dikes, and of the banks, is so
that all parts are to be completed as we advance by pushing end-
canal into the St. Clair lake, as it were, having begun at the
d.

not think it advisable to dredge a channel through first and make
ks afterwards, fearing that the current might carry earth through
t to form a bar where the canal is to terminate in the lake.

far the physical character of the material we are raising from
is highly favorable for the success of the plan of improvement.
s of the cuts, almost vertical, made by the dredges last season,
he present time, have shown no signs of caving in or being
by the current; the material is easy for dredging; the bottom
ent for the driving and holding the piles, and it packs well and
on being put into the banks; the double row of heavy piles set
that the pressure of the earth embankments for the canal banks

as yet does not incline or lean the dikes sufficiently to do the slightest harm. It is probable, however, that in some places we may have to protect the outer slope at the foot of the canal banks from the effects of the small waves that will rise in a severe blow in the lake; the extent of this protection will be determined as the work progresses.

This contingency is set forth in my revised report of 10th December, 1866, for which, however, no estimate could then be made.

Creosoting the timber for the dikes.—On 6th April last I presented an estimate of the cost, and recommended this method for preserving the wood above water from decay. The recommendation was approved by the Chief of Engineers, and the honorable Secretary of War, Mr. Stanton, presented the approval to Congress for an appropriation for this purpose, amounting to $27,300. It is shown that by this outlay the saving for every period of seven years, by preventing decay, would be $28,513. We have facts to prove that after 21 years the timber would be as sound as ever if well creosoted when put in; and Mr. Brunell, in 1850, expressed his opinion that after 40 years the timber would be found as sound as ever. I think it my duty to again recommend an application of this process to as much of the timber as may remain to be put in, with a view of diminishing to the lowest figure the cost of so much of periodical repairs, after the work is constructed, as would be consequent upon the natural decay of timber.

The additional amount, besides that available 1st of July, 1868, required to complete the work without creosoting, and without the contingent item of protecting the foot of the outer slope of the bank, is	$200,000
Creosoting the remainder of the timber to be put in	25,000
Contingent item for protection to foot of outer slope of bank.	20,000
Total	245,000

With this sum appropriated this year, we can have the canal completed before navigation opens in 1870; because, if we are sure of the means, we can double or triple the present force.

Observe, as $86,000 has been assigned to this work out of the general appropriation passed the present session, it will only require $159,000 hereafter to be appropriated to complete this canal.

I take occasion here, also, to remark that the above estimate is (as I said in my first report 15th August, 1866) based for the amount of the dredging upon Captain—now Major General—Meade's survey of 1856. Whether the amount will turn out to be more or less will be decided as soon as I can carry the soundings through the site upon the manner I am now having them made, and as explained on page 143 of this report. Before another annual report will be due, indeed before Congress will act upon this estimate, I shall be able to present any modification to this estimate which may be due to the difference that may be discovered between these soundings and those of 1856.

Cost of future repairs, and preservation.—Without creosoting the timber, it will probably require an average annual expenditure of $5,000; but, if we creosote the timber on putting it in, I estimate $1,500 as sufficient for the annual average repairs.

5.—MONROE HARBOR, MICHIGAN.

This purely artificial harbor is connected with the river Raisin, memorable by its military association, by a beautiful ship-canal, having piers

e lake constructed by the United States. The mouth of the canal, its piers, forms the harbor of Monroe, and through this channel, h is nearly one mile long and 100 feet wide, a large portion of the in flows into the lake; the harbor is about one and a half mile to northward of the old natural mouth of the river. The town of roe is situated four and a half miles above the harbor, at the site ie old village of "Frenchtown," the scene of the "battle and mas- of the river Raisin," in the war of 1812.

ie piers were in a very dilapidated condition when I made examina of them, in January, 1866.

1 July 1st, 1867, we had $24,255 21 available for further repairs.

uring this fiscal year much work has been done, the old parts of the completely repaired with new timber, filled with stones, and planked

ie 300 feet extent interior to the inner extremity of the north pier, e the lake had breached into the canal, washing sand in at every least blow, to be carried out by the current to enlarge the outer has been filled with a very substantial pile pier-work, sheet-piled sides, and filled with bundles of brush and stone.

ewise, on the interior parts of south pier, next to the canal, a sim- ork, found necessary there to the extent of 250 feet, has been con- ed during this fiscal year, and all the contracts have been closed he retained per cent. paid over to the contractor.

ing the spring of 1868 I had a complete survey with soundings on the outer bar by the inspector; this survey shows a sufficient of water over the bar at present for the wants of the commerce of e, which is comparatively small, since the terminus of the Michi- outhern railroad was moved from this harbor to Detroit.

uld the lake, on the north side of the north pier, show signs of ning to breach through the beach and bank of the canal still fur- the west than our new part extends, I propose to stop it next by constructing a wing breakwater, to throw the current of this in an opposite direction. The coming fall and succeeding spring ill show whether this additional work will be necessary.

amount expended during this fiscal year was $13,665, as follows:

tractors for materials and work	$12,428 91
ectors for services	592 67
se of surveying	141 70
ising	1 40
boat for inspector	20 50
tion of office expense chargeable to this work	479 82
Total	13,665 00

ingencies for the year, including inspector's services, nine per f the whole expenditure.

he end of this fiscal year we have left of the appropriation of 23d 866, the sum of $10,590 21. Nothing will be required to be appro- l during this Congress for this work; we shall have ample means le to construct the wing above referred to, and to keep the work d repair for some years to come.

probable estimate of the annual expense of keeping this harbor air I put down at $1,700.

6.—Harbor at Toledo, Ohio.

The operations for the improvement of this have consisted entirely in dredging the old channel to make it wider and deeper, in the Maumee bay, which is strictly the outer harbor of the important commercial city of Toledo.

The amount available on the 1st July, 1867, from the appropriation of 23d June, 1866, and 2d March, 1867, was $35,435 38.

During this fiscal year, by one dredge working from 1st July to November 30, 1867, (when the season for work closed,) there had been dredged, towed away, and dumped, 28,335 cubic yards, and the time of actual working was 854 hours. The work recommenced March 30, 1868, with the same dredge, and from that time to 30th June, 1868, (the end of the fiscal year,) there had been dredged, towed away, and dumped, 18,498 cubic yards, and the time of actual working was 363 hours.

In the whole year 46,833 cubic yards, and time 1,217 working hours; hence the performance of this dredge averaged $38\frac{3}{10}$ cubic yards per hour for the actual time the dredge worked during this fiscal year. The total amount expended in this year was $22,420 37.

To contractor for work done, June, 1867, not paid for till this fiscal year commenced	$2,248 00
To contractor for work done the present fiscal year	18,733 20
For inspector's services	938 52
For buoys to mark line of dredging	20 00
For proportional part of office expenses	480 65
Total	22,420 37

The contingent expenses, including inspector's services for the year, have been 6½ per cent. of the whole expenditure.

To continue operations from 1st July, 1868, we have available $13,015 01.

The annual expense of keeping this elbow channel open cannot be less than $5,000.

I do not think it advisable to ask for another appropriation to be expended in dredging the present channel.

In my annual report of last year, I advocated a different improvement for this important harbor, involving an expenditure of $469,664, for making a straight ship canal in prolongation of the lower reach of the Maumee river, through the shoal bay directly into the deep water of the lake, four miles long, 200 feet wide, with banks five feet high above water, and sides of the banks to be reveted where needed. I again recommend such a canal, believing that the commercial importance of Toledo at the present time, and the wants for refuge of the general commerce, justify the immediate commencement of such a work at the mouth of the Maumee river, which, besides its present commercial importance in being adapted for a good harbor for general commerce, would have a military importance in the event of war again with the British. The river has deep water from the bay six miles up to the city of Toledo, and thence up to the foot of the rapids, nine miles, it is navigable for light-draught vessels.

Importance of Toledo in reference to military means.—Without intending to overrate or draw invidious comparisons, I may in this connection properly notice briefly some of the circumstances which, in the event of war with Great Britain, may justly be regarded as having an important influence in carrying on the military service.

as a lake shipping port has converging to its harbor six exten-
ay lines, viz: from Detroit, 65 miles; from Cleveland, 112
m Cincinnati, 202 miles; from Chicago, (via Michigan South-
miles; from Elkhart, Indiana, (via air line,) 124 miles; and
ouis, 459 miles—total, 1,205 miles. It is also in connection
with Evansville, Indiana, on the Ohio river, by a canal 460
, and south with Cincinnati by one 247 miles long—making
al navigation of 707 miles in extent. Where is there another
nt of connected canal navigation?
nnected by rail and canal with Michigan, Missouri, Indiana,
d Ohio, it is not surprising that this lake shipping port is in
e next to Chicago in the receipt and shipment of breadstuffs,
or in this to any other point on the lakes. The grain trade,
s but one of many others that make up the amount of com-
oledo, and which are more or less to be regarded as a power-
in military operations, whenever found at centers from which
n be conveniently transported to the army. In my opinion,
t to be an "examination and survey" made immediately, to
to estimate the cost of this proposed improvement by a canal.

7.—IMPROVEMENT OF SANDUSKY RIVER, OHIO.

rations for this consist in dredging to obtain wider and deeper
through several shoal places. At the commencement of this
we had available for this work $19,992 40.
st July to close of dredging season, December 7, by one
rking, there had been raised, towed away, and dumped, 20,716
ls, and the working hours were 394. The dredge recommenced
10, 1868, and from that to 30th June the amount of work was,
Whitaker bar, 20,981 cubic yards, and time 521 hours. Dur-
hole year the performance of this dredge was 41,697 cubic
l the working hours 915. The performance of the dredge
$45\frac{6}{10}$ cubic yards per hour for every hour it worked. This
of the Otis patent, single engine, about 15 horse-power.
ount expended during this fiscal year is $11,659 79, as follows:

tors	$11,258 19
ors for services	375 00
engineer officer to inspect	18 05
g	8 55
al	11,659 79

encies for the year, including inspector's services, about $3\frac{1}{2}$
f the total expenditure.
ount available on 1st July, 1868, for further operations, was
This will be enough to bring the bars of the river to a
improvement as regards width of channel very much to the
the navigation now connected with this river; but it will fall
short of accomplishing the total amount of dredging that
ntemplation. To complete the whole work planned from the
ll require an additional appropriation of $34,967. I am of the
at, when improved to this extent, the force of the flow of this
keep the channels clear through all the bars—the outer bar at
of Sandusky river inclusive—from the city of Frémont, at the
avigation, into the lakes.

If we stop dredging when the present available means are exhausted, the annual cost of preserving what we shall have done with these means will probably be $2,000.

8.—IMPROVING HARBOR AT SANDUSKY CITY.

This harbor is well known as being in Sandusky bay, into which the Sandusky river, treated in the previous chapter, empties itself.

The operations for the improvement of this harbor under the appropriation 23d June, 1866, have been confined to dredging the channel through the outer bar, at the outlet of the bay proper into the lake, with a view of attaining a total channel width of 400 feet, and depth of 12 feet below lowest stage of water. The bar is in a very exposed place for dredging.

The amount available for the improvement, 1st July, 1867, was $38,577 90. Since my last annual report to the close of this fiscal year, ending 30th June, 1868, working with one dredge, sand was excavated, towed away, and dumped, amounting to 17,632 cubic yards, the working time being 597 hours.

Observe: 1,599 cubic yards of this was dredged latter part of June, 1867, and not returned in time for my last annual report; it is brought into the present report.

It will be seen that the average performance of this dredge has been about 29½ cubic yards per hour.

The total expended for the above has been $14,244 14, as follows:

To contractors	$13,224 00
To inspectors for services	345 00
For locating channel to be dredged	60 99
Mileage to officer inspecting	68 40
Proportional office expenses	525 75
Total	14,224 14

The contingent expenses, including inspector's services, have been about 7 per cent. on the total expenditure.

To continue operations from 1st July, 1868, we have available $24,353 76; with what may be necessary of this, it is in contemplation to continue the dredging of the outer bar to the extent required, to render this harbor easy of access in all times of weather.

I do not deem it necessary to ask for an additional appropriation at present for this work.

The annual expense of keeping this channel open and free from sand deposits will be about $2,500.

9.—IMPROVING HARBOR AT HURON, OHIO.

Under the appropriation of act 23d June, 1866, this harbor has been repaired to a considerable extent. The repairs consisted in rebuilding the dilapidated portions of the old piers standing above water, and by sinking new cribs, to rest on the foundations of those that had been swept away, to various depths below the water surface, and raising the piers with new superstructure to about five feet above water, and filling the piers with stone, and planking over all.

The amount available on 1st July, 1867, was $28,040 27. During the

year ending 30th June, 1868, there has been expended on this $14,265 96, as follows:

ıtractors	$13,314 52
spector's services	432 00
ıpector's traveling expenses	52 35
ıg	10 20
e to officer inspecting	43 32
tion of office expenses chargeable to this work	413 57
Total	14,265 96

contingent expenses, including services of inspector, have been cent. on the whole amount expended.

unt available 1st July, 1868, for further repairs and preservation, t 31.

contracts for all the materials and work on this harbor were in October, 1867, at which time the old piers had, as far as ıry, been repaired. Afterwards, and during the winter and spring of 1868, a small breach in the old under-water work of one pier, breach in the old superstructure of the other pier, occurred, and ions were left showing that it would be necessary to protect the ke extremity of the new east pier, which seemed to have been hat undermined. The work for repairs and preservation for these e more than covered by the available means belonging to the and these repairs and preservations should be accomplished the close of the working season of 1868.

not think it necessary to call for an additional appropriation for ork for some years to come.

average annual expense of keeping this harbor in repair will ly be about $2,000.

amount available will not only suffice to make the repairs men- but will be sufficient for some years to come to make annual

10.—Improving harbor at Vermillion, Ohio.

operations on this harbor have consisted in repairing the old n places where they were dilapidated, above water and under and building them up to five feet above water, filling with stone, anking over all.

st of July, 1867, the amount available under the specific appro- n of 23d June, 1866, was $3,328 59, which amount was expended this fiscal year, and the contracts under that appropriation were

des this amount, there has also been expended in the repairs and ration of this work, under the general appropriation of 1864, the $5,758 97, making the total expenditure during the fiscal year 56, as follows:

ıtractors	$8,998 39
pector	8 70
f boat and crew	2 50
expenses	77 97
Total	9,087 56

Contingencies all told amounted to less than one per cent. of the whole expenditure.

There is nothing available, 1st July, 1868, for further repairs, unless an allotment be made from the general appropriation of 1864.

Until further damage or deterioration shall show a necessity for it, I do not propose to expend any more on this work, it having been rendered as good a harbor as necessary for the small commerce of the place.

Hereafter the average annual sum required to keep this harbor in repair will be about $2,000.

11.—Improving harbor at Black River, Ohio.

At the commencement of this fiscal year there was available for this work the whole of the appropriation of 23d June, 1866, amounting to $10,000. Nothing has been done on the harbor during the fiscal year, inasmuch as there did not appear to be anything needed for the repairs and preservation, and the harbor being regarded in as good condition as required by the commerce of the place. But before the lapse of many months there will, undoubtedly, be dilapidation of the old parts of the west pier, requiring repairs. The annual average expense of keeping the work in repair will be about $1,500.

The present available sum applied to these repairs, as the necessity for them will arise, will keep the harbor in good condition for several years to come, and no additional appropriation will be necessary.

12.—Examinations and surveys northwestern lakes.

1. *Buffalo harbor.*—Under this appropriation special examinations and surveys had to be made as a preliminary necessity to enable us to plan, estimate the cost of, and locate, the improvements of this important harbor, to be executed under the acts of Congress of June 23, 1866, and March 2, 1867, making appropriation for its improvement.

I placed the execution of these preliminary examinations and surveys under the immediate direction of my then assistant, Brevet Lieutenant Colonel F. Harwood, captain of engineers, to be assisted by Walter Griswold, civil engineer, whom I had appointed inspector of the improvements to be made in the harbor.

The field-work was commenced just about the beginning of the fiscal year, well performed and completed, as also the drawings, in the month of December, 1867, and gave all the desired data for the objects in view.

The total cost of this examination and survey, including inspector's services, was $2,493 39.

2. *Dunkirk harbor.*—Under the same appropriation it also became necessary to make an examination of this harbor to enable me to plan, estimate the cost, and locate the improvements of this harbor, to be made under the act of March 2, 1867. These preliminary examinations cost but little, amounting to only $12 60.

3. *Survey of Port Clinton harbor, Ohio.*—This survey was ordered in virtue of special provision in the act of Congress approved March 2, 1867, making appropriations for examinations and surveys.

The survey was commenced in October, under the immediate direction, in the field, of Henry G. Rothwell, civil engineer, whom I appointed to assist me in this operation. The survey was well executed, mapped, and my plans, estimate of the cost, and location indicated for the improvement, and report rendered 13th December, 1867. The total cost of the survey and office-work was only $234 30. Aggregate cost of 1, 2, and 3, $2,740 29.

onclusion, I have only to add that I have confided the immediate tion in the field, of the operations going on for the improvements ed in this report, to my assistant, Captain G. J. Lydecker, corps of ers, who, besides other engineer duties in connection with Fort e, has rendered efficient services in all required of that highly gent, reliable engineer officer.

ve the honor to be, very respectfully, your obedient servant,

T. J. CRAM,

Col. Corps of Engineers, Brevet Major General U. S. A.

et Major General A. A. HUMPHREYS,

Brigadier General, Chief of Engineers U. S. A.

dered from United States engineer office, Detroit, August 26, 1868.

Summary statement of amounts—fiscal year July 1, 1867, to June 30, 1868.

work repaired, improved, or rveyed for improving.	Amount expended under appropriation of 1864.	Amount expended under appropriations of 1866 and 1867.	Amount of full estimate for completion required to be appropriated.	Amount that can be profitably expended in next fiscal year.	Amount required for annual repairs and preservation.
river, Michigan	.....	$67,942 87	*$398,983 00	$75,000 00	$10,000 00
river, (mouth,) Michigan	.....	4,497 62	20,000 00	50,000 00	6,000 00
river, (mouth,) Michigan	.....	66,928 06	15,000 00	10,000 00	2,000 00
lats, Michigan	.....	15,543 08	159,000 00	200,000 00	‡1,500 00
rbor, Michigan	.....	13,665 00	.....	3,000 00	1,700 00
rbor, Ohio	.....	22,420 37	†469,664 00	100,000 00	5,000 00
river, Ohio	.....	11,659 79	34,967 00	30,000 00	2,000 00
City harbor, Ohio	.....	14,224 14	.....	15,000 00	2,500 00
rbor, Ohio	.....	14,265 96	.....	3,000 00	2,000 00
a harbor, Ohio	$5,758 97	3,328 59	.....	.....	2,000 00
er harbor, Ohio	.....	.....	.....	.....	1,500 00
and surveys northwest lakes	.....	2,740 29	.....	.....	.....

oes not include improving the St. Mary's canal.
upposes a straight ship canal through the shoal of the Maumee bay.
upposes the timber to be "creosoted;" if not, $5,000 will be required per annum.

additional aggregate appropriation required to complete all the works to the standard of improvement required is only $1,097,614, ıe annual expense of afterwards keeping them in repair and pre- g them for the future commerce is only $36,200.

Abstract exemplifying the commerce to which each work contributes, &c., for the fiscal year ending June 30, 1868.

Name of work.	Number of entrances and clearances, sail and steam-vessels.	Total tonnage meas. of all vessels entered & cleared.	Collection district in which the work is.	Near what fort, light-house, or port of entry, the work is.	Amount of revenue collected at the port — duties on imports.
St. Mary's river, Michigan.	2,258	836,135	Mackinaw, Mich	River light. Sault Ste. Mary.	$2,409 71
Au Sable river, mouth of, Michigan.	552	90,897	Port Huron, Mich.	Tawas Point, nine miles.	.....
Saginaw river, mouth of, Michigan.	2,530	528,238	Port Huron, Mich.	Light-house, Bay City.	1,921 9
St. Clair flats, Michigan.	All commerce passing between upper and lower lakes.	Immense.	Port Huron, Mich.	Light-house and range light.	.....
Monroe harbor, Michigan.	167	20,040	Detroit, Mich	Pier light-house....	.....
Toledo harbor, Maumee bay, Ohio.	5,050	1,152,307	Miami, Ohio	Turtle Island light.	16,361 43
Sandusky river, Ohio ...	141	17,055	Sandusky, Ohio .	Cedar Point and Marblehead lights.	.....
Sandusky City harbor, Ohio.	2,801	436,957	Sandusky, Ohio .	Cedar Point and Marblehead lights.	2,658 00
Huron harbor, Ohio.....	Not obtainable.	Not obtainable.	Sandusky, Ohio .	Pier light.....	Nothing of consequence.
Vermillion harbor.....	80	8,000	Sandusky, Ohio .	Pier light.....	Nothing of consequence.
Black River harbor, Ohio.	150	12,000	Cuyahoga, Ohio .	Pier light.....	350 00

The above is as true an exhibit as I have been able to obtain.

T. J. CRAM,
Colonel of Engineers, Brevet Major General.

Abstract of contracts and names of contractors for each class of material and work, for each work, for the fiscal year ending June 30, 1868.

Name of work.	Name of contractor.	What the contractor contracts for.
St. Mary's river, Michigan.	John Brown & Co.	Dredging.
Au Sable river, mouth of, Michigan.	Carkin & Kimball	Furnishing all classes of material, and to do all classes of work.
Saginaw river, mouth of, Michigan.	John Brown & Co	Dredging.
St. Clair flats, Michigan.	John Brown.....	Furnishing all the wood materials and doing all classes of work.
	Moses Hill.....	Furnishing all iron materials.
Monroe harbor, Michigan.	J. M. Sterling	Furnishing timber, lumber, stone, brush, spikes, drift-bolt iron.
	William C. Colburn....	Furnishing nut and screw iron bolts.
	W. H. Mott	Doing all classes of work.
Toledo harbor, Maumee bay, Ohio.	Thomas Dunbar & Co..	Dredging.
Sandusky river, Ohio ...	Thomas Dunbar & Co..	Dredging.
Sandusky City harbor, Ohio.	Thomas Dunbar & Co..	Dredging.
Huron harbor, Ohio.....	F. D. Ketchum	Furnishing timber, lumber, stone, spikes.
	Brooks & Adams	Furnishing timber and lumber.
	James Loveday	Furnishing drift-bolt iron.
	W. H. Mott.....	Doing all classes of work.
Vermillion harbor, Ohio.	Staudart & Richardson	Furnishing timber and lumber.
	F. D. Ketchum.....	Furnishing stone and spikes.
	James Loveday.....	Furnishing drift-bolt iron.
	William Nichols	Doing all classes of work.
Black River harbor, Ohio.	M. Z. Lampman	Furnishing all materials and doing all work, under appropriation of 1864, not requiring advertising.

This is a correct abstract.

T. J. CRAM,
Colonel of Engineers, Brevet Major General.

B 1.

SURVEY OF PORT CLINTON HARBOR, OHIO.

Report of Brevet Major General T. J. Cram, colonel of engineers, on the survey of the harbor of Port Clinton, Ohio, with map, to accompany letter of the Chief of Engineers to the Secretary of War, of the 27th January, 1868.

UNITED STATES ENGINEER OFFICE,
Detroit, Michigan, December 13, 1867.

SIR: I herewith forward my report, containing map of the survey which has been made, plan and estimate of cost of constructing a harbor at Port Clinton, Ohio, anticipating my promise of furnishing all required on the subject by Christmas.

Respectfully, your obedient servant,

T. J. CRAM,
Colonel of Engineers, Brevet Major General.

Brevet Major General A. A. HUMPHREYS,
Brigadier General, Chief of Engineers U. S. A.

Report of survey, with map, plans, and estimate of cost of construction, of a harbor at Port Clinton, Ohio, by T. J. Cram, colonel of corps of engineers, brevet major general, December 13, 1867.

I.—GENERAL CONSIDERATIONS BEARING UPON THE QUESTION OF CONSTRUCTING A HARBOR AT THIS PLACE.

The survey shows that a harbor can be made here at considerable cost. It is a town of some 600 inhabitants, situated at the mouth of Portage river, emptying into Lake Erie, in Ottawa county. For miles above there are extensive tracts of superior hard-wood timber, bordering upon the stream, from which come manufactured oak timber, and lumber, staves, ax-handles, wheel-hubs, spokes, &c., to be shipped; and considerable quantities of fish are also shipped, which are caught in the bay formed by a long peninsula on the east, call Catawba island. There are seven steam mills, a stave and shingle factory, and the river passes through a farming district rapidly improving. The value of the oak and other timber adjacent to the river is great, and would be vastly greater were the obstruction at the mouth removed.

From 13th April to 6th December, (the season of navigation,) 1867, there were, notwithstanding the obstructions, departures of vessels to number of 510, of tonnage 28,035, engaged in the trade, of which the value of the cargoes of timber, wood, staves, handles, hubs, spokes, &c., shipped, amounted to $1,082,399. Most of the timber comes down from Hartford or Oak harbor, 12 miles by land and 14 miles by water, above Port Clinton. The river is navigable for vessels drawing 10 feet to about two miles above Oak harbor, or 16 miles from its mouth. With the exception of one place, where there is a bar 1½ mile above the mouth, this interior bar and the lake bar at the mouth cause much inconvenience. On this interior bar, at ordinary low stages, there is found from four to six feet of water in the channel; at the lowest stage, only four feet.

There is considerable fluctuation in the stage of water at the mouth;

since commencing the survey it has been unusually low, continuing so for several days during the survey, owing to the northwest and westerly gales. In this blow the water fell 2.15 feet below the stage which was established in the survey as the ordinary low stage to which the soundings are referred. During heavy northeast winds the water from the lake forces back the river water with a considerable current up stream. The ordinary outflowing current of the river is two miles per hour; but after piling up for some time the return outflow is from five to six miles per hour. These are circumstances favoring the continuance of a channel, when once well constructed and sides protected, through the lake deposit at the mouth.

The heaviest seas come from the north and northeast. The northwest gales cause but little sea at this place. The head of the bay into which the river discharges is very shoal for a distance, in the shortest direction, of 1,800 feet, from 10 feet water inside across the lake bar, or deposit of 10 feet water in the lake, carrying over the bar at its summit only 2½ feet at ordinary low stages. Following the present vessel track, from 10 feet water inside to 10 feet lake water over the bar, and along which vessels now struggle in entering and departing, the distance is 4,500 feet and of bad direction, parallel to the shore, which is gradually working in upon this long channel, which at ordinary low stage has only six feet at the shoalest place. The bottom is found to be sand overlaying clay, the sand stratum being five feet at thickest place; outside there is clay holding ground. These circumstances are favorable for using piles in construction for dredging, to make a contemplated new and more direct channel, and preserving it after construction.

A 10 feet harbor would be ample for all the commerce, present and prospective, of this place. This site is not adapted for refuge, nor does the general lake commerce require this for a harbor of refuge. The only considerations favoring the expenditure of money here for bettering the condition are those of a local character, and which have been fairly stated.

II.—PLAN OF CONSTRUCTION.

In my judgment, the best the case admits is to make a new channel in the shortest direction, seen bounded by the red lines on the map, turning the outflow in a gentle curve, allowing vessels to easily enter and depart. The new channel to be 200 feet wide in the clear, and to be dredged to a depth of 10 feet below ordinary low stage. The sides of the new channel to be protected by revetments, consisting of large piles driven in a row, (on either side,) at distances apart of 6⅓ feet from center to center; these piles to be connected with a water-sill and binder, just below ordinary low-water stage, by nut and screw and washer-bolts, reaching through sill, pile, and binder; a stringer to be spiked on the outer side of piles of same thickness as binder, and to be five feet below the surface of the water; behind the binder and stringer sheet-piles 4 by 12 are to be driven close to each other and spiked to the binder; the top of the sheet-piles to be capped, as also the tops of the heavy round piles; these cappings to run longitudinally with the canal, and the cappings are connected by transverse pieces at every round pile. The total length of both sides of the canal to be thus revetted is 5,300 feet, or one mile and 20 feet. The cross section of the revetment is shown in figure 1 on the map. The earth, sand, and clay to be dredged out to form the channel to be thrown out and emptied, as much as can be, directly from the "dipper" behind the revetment. Next to the ends of the revetment, as

we go out, we commence and carry out the construction by two parallel piers 12 feet thick, and to rise four feet above water; these to be constructed on my plan of "close pile piers," to be filled with brush in bundles up to the surface of the water, with a four-feet depth of rubble stone on top of the brush. The superstructure to be of 12 inches squ re-sawed oak, drift-bolted side timbers, and cross tied with 8 by 10 sawed oak, and joists to be 2 by 12, gained into upper tier of ties, and planked over with two-inch stuff and firmly spiked. The length of the west pier would be 650, and that of the east 450 feet; the earth which is to be dredged from between these piers to be dumped at a suitable place.

The cross section of the contemplated structure for the piers is shown in figure 2 on the map. It will be seen on the map that, with this location, the present light-house and a range light, say on the revetment at L, would guide vessels in safety, and that they could enter the new channel under the strongest and prevailing winds. For the purpose of guiding vessels into the river through the present vessel track the light-house is of very little or no use, although it is kept up, and of permanent stone structure, with keeper's house also of stone.

III.—ESTIMATE OF THE COST OF CONSTRUCTION.

I. 3,056 cubic yards dredging, interior bar, at 30 cents...	$916 80
II. 13,233 cubic yards dredging, to place revetment and piers, at 30 cents.....	3,969 90
III. 97,612 cubic yards dredging from between revetments and piers, at 30 cents.....	29,283 60
Total cost of material for revetment and piers at present prices of timber, lumber, piles, and iron.....	20,796 84
IV. Total cost of labor (other than dredging to place them) for constructing the revetment and piers, including the filling of the piers, at present prices for such work..	25,983 57
V. Contingencies, at 10 per cent.....	8,095 07
Total cost, (approximate).....	89,045 78

For a less sum than this I do not think a good harbor, adequate to the local business of that river, can be constructed that would have any permanency.

In conclusion, I have to report that I have been ably assisted by Henry G. Rothwell, civil engineer, assistant in the field and office labor of this survey.

I have the honor to be, very respectfully, your obedient servant,

T. J. CRAM,
Colonel of Engineers, Brevet Major General.

Brevet Major General A. A. HUMPHREYS,
Brig. Gen., Chief of Engineers U. S. A., Washington, D. C.

APPENDIX C.

Report of operations in the improvement of Cleveland harbor, Ohio, for the year ending June 30, 1868.

This improvement was under charge of Brevet Major General Cram, colonel of engineers, until the 28th of May, 1868, when it was placed under charge of Major Walter McFarland, of the same corps.

The reports of operations transferred to me by General Cram show that, up to the 28th of May, 608 piles in the extension of the west pier had been driven, 5,000 lineal feet of squared timber, and 388 cords of rubble stone put in position. Since then, and up to the 30th of June, 218 piles have been driven, extending the under-water work of this pier to within 50 feet of its proposed terminus.

This is the only harbor committed to my charge in which the pile pier recommended by General Cram has been authorized. Though this method of construction seems to be somewhat cheaper than the crib construction elsewhere employed, there are several objections to be offered to it.

In the first place, whatever care may be exercised in the driving of the piles, it is generally impossible to bring them close together, and openings, sometimes very large, are necessarily left between them.

In the second place, the permanence of the whole construction depends upon the endurance of the ties which bind the two sides of the pier together, and which, being placed with their lower sides at the water level, are most subject to the process of rot. The connection between the ties and the sides of the pile pier being once destroyed, the tendency of the rubble-stone filling, with its superincumbent mass, will be to press the sides of the pile pier outward and to allow the superstructure to settle between.

To obviate this difficulty as much as possible, I have had *iron* tie-rods inserted underneath the wooden ties, and as the rate of the rusting of iron in these cool fresh waters seems to be very slow, the sides of the piering will probably hold together long after the wooden ties have lost their power through rotting.

Whatever economy there may seem to be in the use of this pile piering, instead of the commoner method of employing independent cribs, I am disposed to believe that the eventual cost must be greater. An entrance through this piling being once effected by the sea, renders the whole structure insecure; but a similar entrance being effected in a pier constructed as ordinarily with cribs, hurts that crib only which it has entered, and which may be entirely replaced without affecting the stability or safety of the remaining cribs.

Even iron ties will eventually, through their own rusting or the rotting of the timbers with which they are united, lose the power of holding the sides of the piling together, and if the depth of the clay which the piles have entered bears but a small ratio to the depth of water and sand through which they have passed, the pressure produced by the stone filling with its superincumbent mass, acting with a longer lever arm, would overcome the resistance offered by the clay acting with a shorter lever arm; the tops of the piled sides would necessarily separate and allow the superstructure to settle without a chance of our preventing it.

The only place, therefore, where this construction seems to me admissible, is where we may penetrate the clay substratum to a depth at least equal to its depth below the surface of the water, and even its application here would not give us the security we get by the crib construction.

The balance available for this work on the 1st of July, 1867, was by General Cram's last annual report		$51,590 45
Expended by him, as per his statement to me	$17,554 32	
Expended by me	3,177 14	
		20,731 46
Available June 30, 1868		30,858 99

Brought forward			$30,858 99
Required for the completion of the extension of both piers, as by his report for 1867		$63,497 00	
Of which he had expended in 1866		8,215 55	
		55,281 45	
Expended by him in 1867–'68	$17,554 32		
By me	3,177 14		
		20,731 46	
Still required to complete pier extension			34,549 99
which is more than the available July 1, 1868, by			3,691 00
which is still to be provided for.			
There is also required, by General Cram's estimate, to give 14 feet depth of water at this harbor			38,622 00
Total			42,313 00

yet to be appropriated to render this harbor what it ought to be.

This amount can be profitably expended before the close of the next working season, and will complete the improvement of this harbor so far as now seems desirable.

Cleveland is in the collection district of Cleveland, Ohio, and is a port of entry.

The amount of revenue collected here within the last fiscal year, and the amount of commerce and navigation to be benefited by the completion of the improvement, is unknown, no answer having been received from the collector of the port to the letter addressed to him by me on the 23d of July last, asking for the necessary information. For copy of that letter see my annual report for Conneaut harbor for the year ending June 30, 1868.

RECAPITULATION.

The work done here during the past year consists in the extension of the west pier by General Cram's pile piering for a distance of 450 feet.

It is expected that the improvement of the harbor will be completed within the coming season, if the additional appropriation of $42,313 asked for is granted.

Balance June 30, 1867	$51,590 45
Expended during the year	20,731 46
Balance June 30, 1868	30,858 99

Which is independent of any balance that then may be remaining in the hands of General Cram, or of any obligations against this work contracted by him, and of which I am uninformed.

Very respectfully,

WALTER McFARLAND,
Major of Engineers.

C 1.

Report of operations in the improvement of Grand River harbor, Ohio, for the year ending June 30, 1868.

This improvement was under charge of Brevet Major General T. J. Cram, colonel of engineers, up to the 28th day of May, 1868, and since then in charge of Major Walter McFarland, corps of engineers.

The only work done here during the year was the repair of the old piers, and the framing of nine cribs to be used in the extension of the east pier, and the placing of four of them.

Here, as in the works at Erie, Pennsylvania, and Conneaut, Ohio, nothing can be determined as to the cost of rendering the harbor permanently servicable, until the effect of the extension of the east pier, now ordered, is observed. The question now to be decided is whether the waters of Grand river, after this extension of the east pier is completed, will be sufficient to keep an open channel into the harbor; and if not, whether this result will be most economically attained by an extension of the west pier also in a direction parallel to that of the east pier, or by the periodical use of the dredge. After the spring freshets of 1869, by which time the extension of the east pier will be completed, we shall be able to decide whether the waters of this river have the power necessary to keep its own channel clear, or whether we must resort to additional means of accomplishing this. Until this is ascertained it will be impossible to say whether other appropriations will be needed or not.

Balance July 1st, 1867, as per General Cram's report for 1867		$53,310 22
Expended by General Cram, as by his statement	$8,128 10	
By myself	93 12	
Total		8,221 22
Balance June 30, 1868		45,089 00
Probable cost of east pier extension, as by General Cram's report for 1867		21,63100
Leaving		23,458 00

available for the extension of the west pier if necessary, or for dredging the harbor out if the action of the waters of the river is not sufficient to keep it clear under the new condition of things. This will probably be enough to put this harbor in the best condition possible, including the building up to the proper level of the superstructure of the two last cribs of the east pier extension, put in during the year, which by the spring freshets have been made to settle at their outer end from six to eight feet.

This harbor is in the collection district of Cleveland, Ohio, which is the nearest port of entry, from which it is distant 29 miles. No information can be furnished concerning the amount of commerce likely to be benefited by the improvement, for the reasons given in my report upon the harbors of Ashtabula and Conneaut, Ohio.

RECAPITULATION.

The work done here during the year consists in the repair of the old piers, and in the construction of nine cribs for the east pier extension,

and the placing of four of them. The action of the spring freshets caused the settlement of the outer end of this length of four cribs to the clay sub-stratum, from six to eight feet below the sand bottom on which they had been placed.

Balance on hand July 1st, 1867	$53,310 22
Expended during the year	8,221 22
Balance June 30th 1868	45,089 00

which is irrespective of any balance in the hands of General Cram, or of any indebtedness contracted by him on account of this work, and, of which I am uninformed.

This balance is to be applied to the extension of the east pier, and, after the effect of this upon the current of the river is ascertained, to the extention of the west pier, the dredging of the channel, or such other operations as may seem best calculated to the improvement of the harbor.

Very respectfully,

WALTER McFARLAND,
Major of Engineers.

C 2.

Report of operations in the improvement of Ashtabula harbor, Ohio, for the year ending June 30, 1868.

This improvement was under charge of Brevet Major General T. J. Cram, colonel of engineers, up to the 28th day of May, 1868, and since then under charge of Major Walter McFarland, corps of engineers.

The work done, up to the transfer of the charge to me, was limited to the repair of the old work, and the preparation for the extension of the east pier.

During the month of June, eight cribs of this extension, of a total length of 240 feet, were built, floated to their position, and sunk, according to the plans prepared for this purpose by General Cram. The work, as recommended in General Cram's report for 1867, can be completed within the next working season, and does not appear to require modification or change.

Balance on hand July 1, 1867		$72,764 29
Expended by General Cram, as by his statement,	$17,461 27	
Expended by myself, in pier extension	6,992 86	
		24,454 13
Balance June 30, 1868		48,310 16
Entire cost of pier extension, by General Cram's report for 1867	$38,526 00	
Already expended upon it	6,992 86	
Still to be expended upon it	31,533 14	
Cost of dredging, by General Cram's report for 1867	18,851 00	
Amount still needed to complete the work		50,384 14
Leaving		2,073 98

still to be provided for, instead of an excess of $3,569, as shown by General Cram's report for 1867.

This arises from the cost of the repairs of the old work amounting to $17,461 27, instead of $11,838, as estimated for last year.

At this harbor both piers are to be carried out to the same extent, and it is anticipated that the action of the waters of the creek will, when this improvement is completed, prevent or delay the formation of a bar at its outer extremity. Nothing further will probably need to be done here after the execution of the work herein contemplated than the occasional repair of decaying wood-work.

Ashtabula is in the collection district of Cleveland, and the nearest port of entry is Erie, Pennsylvania, distant 40 miles—Cleveland being 55 miles west of it.

No official information has been received concerning the amount of commerce and navigation to be benefited by the completion of the improvement, though the growing importance of the town of Ashtabula, from its proposed connection with the coal regions of Ohio, will undoubtedly make it considerable.

RECAPITULATION.

The work done here during the year consists in the repair of the old piers, and the extension of the under-water work of the east pier for a distance of 240 feet.

It is expected that the improvement of this harbor will be completed during the next working season.

Amount expended	$24,454 13
Balance June 30, 1868	48,310 16
Still required over last year's estimate	2,073 98

And this is independent of any balance still remaining in the hands of General Cram, or of any indebtedness on account of this work contracted by him and of which I am, as yet, uninformed.

For a copy of my letter to the collector of the port of Cleveland, asking for the information required by Congress concerning the commerce of this place, see my report on Conneaut harbor, Ohio.

Very respectfully,

WALTER McFARLAND,
Major of Engineers.

C 3.

Report of operations in the improvement of Conneaut harbor, Ohio, for the year ending June 30, 1868.

This improvement was under charge of Brevet Major General T. J. Cram, colonel of engineers, up to the 28th of May, 1868, and since then under charge of Major Walter McFarland, corps of engineers.

From the report of operations turned over to me by General Cram, it appears that the work done upon this harbor, up to the 28th of May, consisted in the repair of the decaying portions of the old east and west piers. Since that date, and up to the 30th of June, nothing more has been done than the collection of the material necessary to the completion of the west pier extension.

In the spring of 1868 a heavy freshet occurred in Conneaut creek, and the

passage of the water being obstructed by the blocking of the ice between the piers, it made its way over the low land at the southern end of the east pier, and formed a new channel for itself to the lake, about 150 feet broad. This new channel must be closed, and the expense of doing this will not fall short of $8,000 or $9,000, which must be provided independently of the $10,638 called for by General Cram in his last annual report for this work.

Of the appropriations for this harbor, there were available on the 1st of July, 1867, according to General Cram's official report for that year, $27,378 19. He has expended, as per his statement to me, $11,181 74, leaving $16,196 45 available on the 30th of June, 1868, irrespective of any balance in his possession, or any obligations contracted by him for this work, of which I am uninformed.

The work remaining to be done is the repair of the break caused by the freshet of March, 1868	$9,000 00
And, as by last year's estimate, the extension of the west pier	22,771 00
Dredging the channel	6,181 00
Total	37,952 00
Deducting the balance given above	16,196 45
There remains	21,755 55

to be provided for by future appropriations, all of which, with the balance now on hand, can be profitably expended before the close of the next working season.

This, so far as we can judge at present, will complete the work of improvement at Conneaut harbor, as, in the case of Erie, we can only tell whether an extension of the east pier will be necessary after the effect of the extension of the west pier is ascertained. It is possible that dredging alone will answer the purpose of keeping a clear channel here; but before being able to decide which of the two methods will be most economical, we must ascertain clearly the effect produced by the new construction.

Conneaut, Ohio, is in the collection district of Cleveland, and the nearest port of entry is Erie, Pennsylvania, distant 27 miles; but what amount of commerce and navigation would be benefited by the completion of the public works there I am unable to state, as I have received no answer to my letter to the collector of the port of Cleveland asking for the necessary official information, a copy of which letter is transmitted herewith.

RECAPITULATION.

The work done here during the year consists in the repair of the old east and west piers.

A freshet in the spring of 1868 caused the waters of Conneaut creek to break through behind the east pier into the lake. This break will have to be closed, the cost of which will be about	$9,000 00
Cost of extending west pier	22,771 00
And dredging channel, as by last year's estimates	6,181 00
Total	37,952 00

Brought forward		$37,952 0
Balance July 1, 1867	$27,378 19	
Expended by General Cram	11,181 74	
Available June 30, 1868		16,196 4
Balance		21,755 55

still to be provided for in order to complete the work so far as now appears to be necessary.

Very respectfully,

WALTER McFARLAND,
Major of Engineers.

Duplicate to accompany annual report for Conneaut harbor, Ohio, for the year ending June 30, 1868.

UNITED STATES ENGINEER OFFICE,
Erie, Pennsylvania, July 23, 1868.

SIR: Under the provisions of the act of Congress making appropriations for the repair, preservation, and completion of certain public works, approved March 2, 1867, it is made a part of my duty to furnish with my annual report information upon the following points concerning the works in my charge, viz:

I. The collection district in which each work is located.

II. At or near what port of entry, light-house, or fort, each work is located.

III. What amount of revenue was collected at the nearest port of entry to each work for the last fiscal year.

IV. As far as practicable, what amount of commerce and navigation would be benefited by the completion of each particular work.

I have respectfully to ask that you will cause to be furnished me from the records of the custom-house the information herein called for, so far as it relates to the harbors of Cleveland, Grand river, Ashtabula, and Conneaut, Ohio.

Very respectfully, your obedient servant,

WALTER McFARLAND,
Major of Engineers.

Hon. COLLECTOR *of the Port of Cleveland, Ohio.*

C 4.

Report of operations on the improvement of Erie harbor, Pennsylvania, during the year ending June 30, 1868.

This improvement was under charge of Brevet Major General T. J. Cram, colonel of engineers, up to the 28th day of May, 1868, and from that date until the 30th of June, 1868, under charge of Major Walter McFarland, corps of engineers.

The reports of operations turned over to me by General Cram show no other operation than the dredging and removal of 37,222 cubic yards of sand for that part of the year during which he had charge of this work, and without specification as to when the dredging was done. It

is understood, however, from contracts previously made, to have been through the outer bar, and for a width of about 200 feet from the south side of the north pier. Examination shows, however, that besides this dredging, the extension of the north pier, recommended by General Cram in his report for 1864, which had been approved of, and for which an appropriation had been made, was commenced about June, 1867, and nearly completed by October of that year.

In September of the same year a storm of considerable violence arose, which caused a settlement and partial overturning of the outer portion of this extension for a distance of over 300 feet, injuring the structure to such a degree as to cause the appointment of a board of engineers to determine the cause of the disaster, and to recommend such measures as might seem to them necessary for its repair. The recommendations made by this board were approved by the Chief of Engineers, and General Cram was ordered to prepare the necessary plans and specifications for carrying them out. This was accordingly done; his plans and specifications were approved, and sealed proposals for repairing the damaged pier and for dredging the inner channel of the harbor were called for by public advertisement about the middle of May, 1868, and resulted in the letting of the contract for repairs to Mr. Nicolls, of Detroit; and for dredging, Lee & Dunbar, of Buffalo; work under the contracts to be begun on the 1st and 9th of June, 1868, respectively.

During the few weeks that elapsed between the commencement of these operations and the close of the fiscal year ending June 30, 1868, Nicolls placed 215 cords of rubble stone in rip-rap on the north side of the damaged pier, and Lee & Dunbar removed from the inner bar 2,035 cubic yards of sand.

There have been expended in the improvement of this harbor during the fiscal year ending June 30, 1868—

By General Cram, (according to his own letter statement to me)	$43,873 49
By myself	3,610 09
Total	47,482 58

By engineer department letter to me, dated June 24, 1868, there was then in the treasury of the United States of the appropriation for the improvement of Erie harbor	$15,961 00
Amount expended by me, out of this balance, up to June 30	3,610 09
Balance July 1, 1868	12,350 91

To which must be added any balance remaining in the hands of General Cram and belonging to this appropriation, of the amount of which I am uninformed.

The work that still remains to be done at this harbor consists in the completion of the repairs of the damaged pier, the completion of the dredging of the outer bar, begun last year, and the dredging of the channel across the inner bar to a width and depth rendered necessary by the increasing commerce of this port.

The amount of tonnage which has entered this port in the month of June, 1868, is nearly three times what it was for the same month in 1865, and about double what is was for June, 1866. In 1865, as shown by the custom-house records here, it was a rare thing to find a vessel rating as

100 tons in the harbor—from 100 tons to 250 being about the tonnage of the large traders. To-day vessels of 600 up to s burden are common in the bay, and some range as high a s and are 200 feet in length, and this change has occurred since ovements began. For the latter class of vessels a channel not 300 feet in width ought to be provided through the inner bar, nt it is but 100 feet wide,) which would make it of about the th as the channel between the piers. To dredge this out to a 14 feet at low water would cost probably not less than $35,000. plete the dredging of the outer bar, where, to render vessels safe against touching bottom in stormy weather, we should go leeper, would cost probably $5,000. To complete the repair of ged pier, according to the plans and estimates made by Gen- and approved by the Chief of Engineers, will cost $16,000.

pier	$16,000 00
outer bar	5,000 00
inner bar	35,000 00
	56,000 00
July 1, 1868	12,350 91
	43,649 09

vided for. This will be covered by the $10,000 set apart from al appropriation, of which I was notified by department letter ril 2, 1868, addressed to General Cram, and by allotment of rom the general appropriation recently made, of which I was by department letters of July 3 and September 3, 1868. This plete the work of improvement for Erie harbor as nearly as it mpleted. It is certain that a bar will again form at the mouth rbor, about the extremity of the pier, after the lapse of a few Whether this tendency to form a bar will be best remedied by dredging or by an extension of the south pier, can only be deter- nen the rate of growth of this bar for the present extension is ed. If that rate be a slow one, as seems probable, small appro- or dredging at intervals of a few years will suffice, but in what or at what intervals it is impossible now to say. Erie is a port in the collection district of Erie. The amount of revenue col- ring the fiscal year ending June 30, 1868, by the custom-house f the place, is shown to be $11,373 30. Two thousand one hun- nine vessels, with an aggregate capacity of 563,462 tons, were nd cleared at this port during the same period.

RECAPITULATION.

rk done here during the year consisted in the removal of a por e outer bar, giving a channel across it about 200 feet wide and ep at low water, and in extending the north pier 500 feet out. This extension was so badly damaged by a storm in September, t it became necessary to order a board of engineers to examine ondition and to recommend measures for its repair. This was gly done; the recommendations were approved, bids called for tisements, contracts entered into, and the work of repair begun 1868.

ork of repair will be completed within the present fiscal year, proved, the dredging of the outer bar to a depth of 16 feet, and

the widening of the inner channel to 300 feet with a depth of 14 feet at low water, can be accomplished within the same period, all at a probable cost of $56,000, which amount is already provided for by the balance of special appropriation still unexpended, and by allotment from general appropriations for works of river and harbor improvement.

Amount expended during the fiscal year ending June 30, 1868, $47,483 58.

Very respectfully,

WALTER McFARLAND,
Major of Engineers.

I transmit herewith abstracts of bids and abstracts of contracts for Erie harbor, Pennsylvania.

W. McF.

Abstract of bids for doing work at

Number of bids.	Names and residence of bidders.	CLASS A. Item 1.—To take off from the works put in by Vincent & King, with as little injury as possible, the planks, joists, and upper timbers from the north pier, new extension, for an extent pier-wise, of about two hundred feet.	Item 2.—To take out from the north side of the pier the ballast stone, say seventy-one cords, more or less, and put the same overboard along that face; placing the stones thus taken out on the natural bed of sand in the shape, all along, of a rip-rap, fifteen feet wide at bottom, and gradually rising from nothing on the north edge to a height of five feet next to the pier. The length of this rip-rap, pier-wise, will be about two hundred feet.	Item 3.—To dredge a trench in the sand, close up to the bottom of the pier, on the south side thereof, for a length of two hundred feet, and to an average of fifteen inches depth of cutting. There will be about one hundred and seventy cubic yards of sand to be thus dredged and dumped.	Item 4.—To pull up as many of the piles that may be judged to have been driven defectively as may be required to be pulled.	Item 5.—To drive as many piles in, and for staying the work, as may be required,
		33,170 B. M.	71 cords.	200 cubic yards.	25 piles.	60
1	*William Nicholls, Detroit...	*Dollars.* 10 $331 70	*Dollars.* 2.50 $177 50	*Cents.* 50 $100	*Dollars.* 4 $100 00	*Do*
2	William H. Douglass, Buffalo, N. Y.	.....	.....	.....	.....	....
3	Daniel E. Bailey, Toledo; Alonzo D. Denny, Detroit.	10 $331 70	3 $213 00	45 $90	8 $200 00	
4	Patrick Smith, Cleveland, Ohio.	12 $398 40	7 $497 00	60 $120	10 $250 00	
5	*Lee & Dunbar, Erie	10 $331 70	3 $213 00	50 $100	8.50 $212 50	

* Contracted with.

harbor, Pennsylvania, May 20. 1868.

				CLASS B.*	Remarks, names of bondsmen, &c.
Item 6.—To furnish and put properly in the piers or pile-work additional [illegible] may be required, any two hundred cords, more or less.	Item 7.—To frame, fit, fasten in place in the superstructure all timber that may be required upon the work of the inner two hundred feet of the said extension of the north pier.	Item 8.—To replace and fasten the joists and covering plank upon this portion of the work, in the same manner as before their removal.	Total of class A.	Item 1.—To dredge, tow away, and dump the earth raised at such place as the engineer in charge may direct—the present interior channel of this harbor—at such place, in such direction, to such extent, width, depth, and manner as the engineer in charge shall direct, to the amount of 16,668 cubic yards, more or less, as the funds already appropriated shall justify—the measurement of the dredging to be made by the engineer in charge in the natural bed before dredging, upon the data furnished by the survey, under the direction of the Lake Survey, in 1856–'66, and the contractor to be paid upon this estimate. The dredging to be commenced as soon as the legal papers can be executed with the contractor, and all to be completed on or before the first of September next, and as much sooner as the engineer in charge may direct.	
200 cords.	1,920 running feet.	10,130 feet B. M.		16,668 cubic yards.	
Dollars.	*Cents.*	*Dollars.*		*Cents.*	
12	10	7		.....	Francis Adams & Jas. H. Jones, Detroit, bondsmen.
$2,400	$192 00	$70 91	$3,552 11	.....	
.....	.....	.....	.....	32	T. B. Gallagher & J. E. Harris, Buffalo, bondsmen; received telegram from W. H. Douglass, withdrawing his bid, before he could be notified that he was the lowest.
.....	.....	.....	.....	$5,333 76	
12	12	8		45	Thos. Courtright, Painesville, O., & J. J. Bagley, Detroit, bondsmen.
$2,400	$230 40	$81 04	$3,846 14	$7,500 60	
13	16	18		44	J. Obwill, & Wm. Quigley, Cleveland, bondsmen.
$2,600	$307 20	$182 34	$4,714 58	$7,333 92	
13	12.5	8		37.5	Jas. H. Lee, & Wm. H. Abell, Buffalo, bondsmen.
$2,600	$240 00	$81 04	$2,458 24	$6,250 50	

* Class B was advertised separately and bid for separately.

I certify this to be a true abstract of the original bids.

T. J. CRAM,
Colonel Engineers, Brevet Major General.

Abstract of contracts for doing work at Erie harbor Pa., entered into May 26, 1868, to accompany annual report for year ending June 30, 1868.

Name of contractor.	Work contracted for.
William Nicolls, of Detroit....	Repair of damaged pier as per bid shown on the abstract of bids accompanying annual report for year ending June 30, 1868.
Lee & Dunbar, of Erie and Buffalo.....	Dredging inner channel as per bid shown in the abstract of bids accompanying annual report for year ending June 30, 1868.

I certify this to be a true abstract of the contracts entered into for Erie harbor.

WALTER McFARLAND,
Major of Engineers.

C 5.

UNITED STATES ENGINEER OFFICE,
Detroit, February 22, 1868.

I herewith forward a special report and attached to it a "statement of materials and work" in respect to Erie harbor. I respectfully request an early attention to both, and the necessary instructions for two reasons

1st. It is desirable to let Vincent & King know their fate in respect to payment.

2d. If the remedy suggested be approved, we should see immediately about getting the materials under way.

Very respectfully, your obedient servant,

T. J. CRAM,
Colonel Engineers, Brevet Major General.

Brevet Major General A. A. HUMPHREYS,
Brig. Gen., Chief of Engineers U. S. Army.

Special report upon new work extension of north pier, Erie harbor, Pennsylvania, February 22, 1868.

In the order September 12, 1866, from engineer department, I was directed to make the construction of this to "consist of crib-work ballasted with stone." My own plan and estimate submitted contemplated this construction to consist of a pile pier ballasted with stone but the order above quoted overruled my plan; accordingly new plans were made with much labor and care to comply with the directions from the engineer department, and hence the reason of calling them the "government plans." The cribs to be 30 feet long and 18 feet wide, to rest on a level bottom obtained by dredging 12 feet below low-water surface, and stayed with a pile in each interior corner; and immediately to be filled with stone, and to have a superstructure six feet high, also filled with stone and planked over.

The width given to the cribs was four feet wider than the old pier, which had been placed on a similar sand bottom and at the same depth

without stay piles, with six feet superstructure, all filled with stone, which I found had stood well for many years, under precisely such action upon it as would come upon the proposed new extension.

Herewith is drawing A, showing the exact mode of constructing the work to be done under contract by Vincent & King, who were furnished with a copy of this drawing, with bills of materials and specifications to guide them under the articles of agreement.

Much personal labor had been bestowed in this office, also much by myself at Erie, to explain to the inspector and the contractors the details of the plans and specifications, with an assurance that no departure from them could be tolerated, as such permission would be tantamount on my part to a violation of the contract.

Timber and iron were furnished as fast as the contracts with Brooks & Adams for the former, and James Loveday for the latter, required. The inspector, Irvin Camp, a civil engineer, reported, 3d July, as having been done in June, as follows: "We have got *a good line* and a good level on 120 feet of cribs now sunk and filled to water surface with stone," and sent the amount of work done to be paid for. Supposing that this meant four of the 30-feet cribs sunk line, stayed with the piles and filled according to the government plans, I made out vouchers and paid the contractors accordingly. Shortly after, to my surprise, I learnt that the stay-piles were not driven; whereupon I directed the inspector to return no work as done under water until the stay-piles were driven and the stone immediately put in, as this was in accordance with the contract; and also directed him to notify the contractors immediately that I would neither accept nor pay for any work unless done in accordance with the contract. This notice was served on the contractors. They, however, persisted in going on putting in cribs, which I supposed to be 30-feet cribs, and filling with stones, without, as I afterwards learned, driving the stay-piles; making boxes in the corners, so as to drive the piles at their convenience after completing the superstructure.

Along in August, I think it was, one of the contractors, Mr. Vincent, came to Detroit to get money, on a report from the inspector to the effect that 240 feet more of cribs had been sunk, filled with stone, though not stay-piled. Questioning Mr. Vincent, I now discovered for the first time that, instead of framing the crib-work in single cribs of 30 feet, as the government plans called for, they had all the time been framing cribs 120 feet long, assuming that this mode of framing made stronger cribs than the government plan of cribs, and that he "thought they had much improved the work." I endeavored to point out his error, but failing to convince him I told him he had violated the conditions of the contract, and that I could not nor would I pay a cent for work in this manner, and advised him unless he drove the piles and filled the work immediately, he would be running a very great risk of having his cribs knocked out of line by the first heavy blow; but that if he had put in 30-feet cribs, and piled and stayed them according to government plans, the risk afterwards would of course fall upon the government. To this he replied that he could "obtain money enough to carry on the work without calling upon the United States, and that he should continue by putting in another crib 120 feet long, which would carry the under-water work to the whole extent contemplated, and would take upon himself all the risk of a failure." I again tried to impress upon him the magnitude of the risk, which might be so great as not only to deprive him from getting any pay, but involve the contractors in the disagreeable consequence of having to pay, either they or their bondsmen, to the United States the cost of government materials they were using up.

It was at this interview that I learnt the particulars of another viol tion of the government plans; which is, that instead of starting the ne work exactly at the end of the old pier, they started at a point east it, thus leaving a gap of 17 feet between the old and new work; th because, from the nature of the bottom in that space, they could n easily dredge to obtain the required depth. This gap they filled wi an interpolated crib 17 feet long after they had put in the last 120 fe crib.

Up to 7th of September the inspector had been writing to me of "t perfection" and "stability" of Vincent & King's line of under-wat piering without any piles, and I was favored with a treatise of some s pages showing how groundless were my apprehensions of it ever bei moved by a storm on Lake Erie; the substance was to prove that th plan was superior to the government plan. The method of framii their cribs is shown on sketch B.

On the 7th of September, however, the test came in a violent nort easter; and after the storm the outer upper northeast corner, (see sket C) of their work was found "canted so that it was five feet below proper first level, and five feet out of its original alignment, causing contortion and twisting of their line of cribs extending from the out end westwardly for 130 feet," *i. e.*, for the whole outer crib and for 10 fe of the next crib. The contortion and twisting are shown as clearly as pos ble in diagram Nos. 1 and 2, sketch C. It seems that after the careeni to the north commenced, they kept bolting on timbers upon the *north si* —a gross mistake, to build up that side, as Mr. Vincent informed n "to keep the wood-work up to the surface of the water," thus addi weight after weight to that side, which of a necessity must add mc and more to the liability to careen in that direction.

Every northeast storm, of which there occurred a succession of ve severe ones, caused more careening. The October storm left it in a po tion shown by diagram No. 3. After this the weather became calm, a it seems that, as the work had to them apparently become stationa they put the superstructure upon the 258 feet of inner portion, and th drove piles down from the top through the boxes which they had ma This was another miserable expedient, as piles set in that manner cou not be made to have a proper or firmly bolted connection with the und water crib-work. Besides driving from that height it would be imp sible to make the piles penetrate more than from six to eight feet i the bottom, whereas the government plans, requiring them to be imr diately driven after setting of the cribs, required and rendered it pr ticable to drive them to a penetration of 12 feet into the bottom, a also to firmly connect them with the timbers of the crib they were tended to stay. Their excuse was that they "could not get a pile-dri in time to drive the piles immediately after setting their cribs, and t it would be much easier to set a pile from on top of the superstructu and from there drive the piles down through the boxes." In this m ner they stuck in as many piles as they could until they came to wh the work was so twisted that their mode of piling had to cease. A this the inspector returned as "finished work" the 258 feet inner tion of the extension, and the 248 feet of the outer portion as "unfini work."

Vincent & King's letter followed the return, in which they c payment for their work as if it had been done according to co and upon the government plans; being satisfied, as they said, and co to say, that "the displacement, careening, &c., were in conseque no fault of theirs." I declined receiving the work or paying for i

instructed, after time and opportunity should be at my command, to lay the whole subject in a proper light before the engineer department. I may say here that I have been favored with much argument to show that the pier must have careened, sunk, and been twisted, even had it been put in according to government plans. Theories have been advanced upon "peculiar currents there under these violent northeast storms," and when I have asked, "Have you ever been there, or heard one say that he had been there, during one of the storms and witnessed the current you speak of?" the answer has invariably been "No; no one can get there, or stand there to witness in such storms."

On the 30th of December, 1867, the inspector reported as follows: "During the recent northeast gale, the most violent experienced this season—and, I may add, for many seasons—at the close of which the water was three to four feet lower than ever known, the finished portion (the 258 feet inner part,) settled over to the north so as to thrust the piles up through the planking from two to three feet. This process of careening from undermining has been going on, extending gradually westwardly from the outer or eastern end of the pier, with each and every recurring northeast gale, which exceeded in force the gale in September last, which first undermined and careened the pier some four to five feet, until it had reached some 22½ feet out of line at eastern end. This process has gone on uninfluenced by the piles, driven or undriven, the piles driven being unequal to the careening pressure of the cribs after the foundation had been washed away beneath them to the depth varying from 2 to 15 feet, commencing at outer end and going inwards." "I write thus fully in closing the year's report in consideration of the bearing these facts may have in enabling you to come to a satisfactory conclusion in your settlement with the contractors, and also for the bearing they may have in future operations at this harbor."

The condition of the work put in by Vincent & King, as thus reported, up to December 30, is as clearly as possible represented in diagram No. 5, sketch C.

I have already explained how the piles were stuck in and driven from top of superstructure, and it is not surprising that, put in in this manner, they should have had but partial effect to prevent the careening. The question at issue between the government and Vincent & King, is not whether the piles would have kept the work from careening; the question is, how far Vincent & King are to be paid for work they put in not in accordance with the plan they contracted upon? I think I have now given all the facts bearing upon the question.

The remedy I would propose is this: Settle with Vincent & King upon a basis set forth in one of the chapters under the head of "statement," attached to this report, and make use of the existing work of Vincent & King as a "breakwater" to shelter and protect an interior work to be put on the inside of their work.

The work I would put in is the close-pile pier, filled with brush in bundles up to the low-water level, and the superstructure to be filled with rubble-stone and planked over. The work should start at a point about 250 feet from the end of the old pier, and extend out to 12 feet water —referred to low-water stage. The work would be about 250 feet in length, and should be 18 feet feet wide from out to out, and rise six feet above the low-water level. It could be legally built under the existing contracts, all but furnishing the brush, which would have to be advertised for, and would cost, according to the prices in the contracts, and to what I estimate the brush at, ($50 per cord,) $12,495 89.

The cross section of the work, as well as the general plan, are represented on sketch D, herewith sent.

Every foot of work, I find, would cost $50, and it will therefore be easy to tell how much more or less than the above sum it would cost as we should find it necessary to exceed or fall short of 250 feet running of the work.

I have the honor to be, very respectfully, your odedient servant,

T. J. CRAM,
Colonel Engineers, Brevet Major General.

Brevet Major General A. A. HUMPHREYS,
Brig. Gen. Chief of Engineers U. S. A.,
Headquarters Corps of Engineers.

P. S.—I would add that Vincent & King have claimed to do the worl which may be adopted to remedy the evil under their contract. I shoul not object, and really think the lesson they have received will teac them never again to depart from the plans of the engineer.—T. J. C.

Statement of materials and work delivered and claimed to have been don by contractors for extension of north pier, Erie harbor, Pa., drawn u from official returns of the inspector, Irvin Camp.

I. Suppose a settlement upon the basis of the United States con senting to accept the work as put in by the contractors, Vincent & King paying Brooks & Adams for all the timber and lumber the inspector ha returned as having been delivered by them for the work, whether fu nished by Brooks & Adams, the proper contractors, or by Vincent & King, as sub-contractors under Brooks & Adams, paying Vincent & King (the proper contractors) for all the spikes, nails and piles the furnished, and paying the proper contractor (Loveday) for all iron fu nished, whether ordered by the engineer officer in charge, or by Vincen & King, and paying Vincent & King for all work done by them a returned by the inspector of timber and lumber. Mr. Camp returns a having been delivered in all by Brooks & Adams, contractors, (an Vincent & King sub-contractors under Brooks & Adams,) up to 31 December, 1867:

Square timber, 39,676, (a) running feet.....	457,044 ft., b. m.
Joists, plank, boards, scantling, (lumber).....	34,297 ft., b. m.
Total.....	491,341 ft., b. m.
And left on hand, of the latter.....	10,240 ft., b. m.

Mr. Camp also returns as having been put into the pier by Vince & King, (contractors for the work,) up to December, 1867, as follows Joists, planks, scantling, and boards to the amount of 22,869 fe board measure. Now observe the difference existing between this a the difference between the amount delivered and the amount on ha leaves an amount lost or wasted, of 1,188 feet board measure, which the contract price of $24 50 per M, comes to $29 10,[1] which would be proper item of debit against Vincent & King. Again, Mr. Camp return as having been put into the work excluding piles, in all, up to 31st December, 1867, 28,400 running feet square timber under water, and 10,605 running feet of ditto above water, both amounting to 39,005 (b) running feet.

Now observe: the difference between (a) and (b) is 671 running feet, equal to 8,052 feet board measure, and is the amount less put into the

work than delivered; and Mr. Camp reports no timber on hand 31st December, 1867; consequently Vincent & King must have lost or their workmen wasted 8,052 feet, board measure, of square timber at $24 50 per M, amounting to $197 27(2), and this also becomes a proper debit item against Vincent & King. Again, the government plans called for a specified number of sticks of timber, 25 feet and upwards in length, to the amount of 205,200 feet, board measure, the price of which was $34, and the price for all under 25 feet was $24 50 per M. Now I have already had to pay to Brooks & Adams, (the only contractors recognizable for furnishing the timber and lumber,) for sticks of 25 feet length and upwards to the amount of 218,028 feet, board measure, making an excess of long sticks, over and above what the government plans called for, of 12,828 feet, board measure. This excess is in consequence of the contractors (Vincent & King) having framed the cribs contrary to the government plan, in putting long and higher priced timber where short and lower priced sticks were planned to go in the structure. The difference in price between the long and short timber is $9 50 per M, and this excess will amount to 12,828 × $9 = $121 87(3), and this becomes a proper item of debit against the contractors, Vincent & King.

The three items (1) (2) (3) of debit thus made out, it will be seen, amount to $348 24(c), and this should be paid by Vincent & King, upon the basis of settlement now under consideration in chapter I.

Again. For the whole pier extension of 480 feet, the government plans called for 478,273 feet, board measure. Of this, however, I had ordered from and paid Brooks & Adams for furnishing and delivering only 440,368 feet, board measure, when I learned of the continued departure from the government plans in the execution of the work; the difference between this and 491,341 feet, board measure, which has actually been furnished by Brooks & Adams, and their sub-contractors, Vincent & King, is 50,973 feet, board measure. And upon the basis of settlement under consideration the United States would be in debit to Brooks & Adams for this item, amounting, at $24 50 per M, to $1,248 84(4), and be the owner of the 10,240 feet, board measure, of the lumber on hand and not used up.

SPIKES AND NAILS.

The government plan required 600 pounds wrought spikes and 224 pounds 10*d.* cut nails, and for furnishing both Vincent & King were the contractors, at 10 cents per pound. Up to the time of learning of the departure from the government plans, there had been furnished by my orders only 728 pounds spikes and nails. These I had paid for. The total spikes and nails returned by the inspector as having been furnished by Vincent & King is 883 pounds, of which they have used up in their work 623 pounds, leaving 260 pounds spikes on hand not used up 31st December, 1867.

Upon the basis of settlement now under consideration, the government would therefore have to pay Vincent & King for 105 pounds spikes and nails at 10 cents per pound, amounting to $10 50(5), and be the owner of the 260 pounds spikes on hand.

It is to be observed here, that the excess in spikes and nails Vincent & King have furnished is 155 pounds above what I had ordered up to the time of learning the departure from the government plans, and the excess is 59 pounds above what the government plans required for the whole work

PILES.

Of these the inspector reports 64 as having been delivered by Vincent & King, the proper contractors, of which 44 have been driven by Vincent & King, as all they can possibly drive in the work put in by them; leaving 20 on hand not used up to December 31, 1867.

Now it is to be observed that the government plans required "30-feet separate cribs" to be sunk, and a pile immediately driven in each interior corner of the crib, and the crib to be immediately filled with stone—the cribs and stone to come up to the surface of the water; and after all the cribs had been put in and thus stayed with the piles and stone ballast, the superstructure was to be put on, filled with stone, and planked over. But Vincent & King framed their work in cribs 120 feet long, sunk them *all* end to end in line before driving a stay-pile, making boxes in the interior to receive the piles; filled in the stone and put on the superstructure before driving a pile; and afterwards undertook to drive the piles from the top of the work down through the boxes, succeeding in driving 44, but failing to drive any more in consequence of the careening of the outer part of the long line of their unstayed crib-work.

Upon the basis of settlement under consideration, however, the government would have to pay Vincent & King for the 64 piles, at $8 per pile, as per contract, amounting to $512(b), and would own the 20 left on hand.

IRON.

The government plans required for the completion a specified number of pounds of drift bolt-iron, all of which was at once ordered by me, and furnished by the proper contractor, James Loveday. Further than this I neither ordered nor authorized Vincent & King, nor any one else, to order.

The inspector, however, returns, as having been ordered from Loveday and put into their work by Vincent & King, an excess above what the government plans required of 2,314 pounds. Upon the basis of settlement under consideration, however, we should have to assume this item as a debit against the United States, and pay Loveday for it under his contract at $5\frac{1}{8}$ cents per pound, amounting to $118 58(7).

Work done by Vincent & King, the proper contractors for doing all work.

The government plans required for completion the whole 480 feet pier extension, as follows: Dredging to pose the cribs on a level bottom 12 feet below water surface. The amount for this was approximately estimated at $833\frac{65}{100}$ cubic yards, but the actual amount proved to be more. The total dredged for posing the crib, as returned by the inspector, amounts to an equivalent of 1,566 cubic yards; of this, 1,425 cubic yards was paid for before learning of the continued departure from the plans, leaving 141 cubic yards yet to be paid for to Vincent & King upon the basis of settlement now being considered, amounting, according to contract price of 50 cents per yard, to $70 50(8).

TIMBER AND LUMBER.

The government plans required—

Square timber to be put under water, running feet	30,618
Sixty-four round piles to be driven, considered as under water 28 feet, running feet	1,792

Square timber to be put in above water, running feet	8,632
Joists, plank, scantling, and boards, (which call lumber,) feet, board measure	28,969

The inspector returns in all, as having been put into their work by Vincent & King, up to December 31, 1867, as follows:

Square timber put in under water, running feet	28,400
Driving of 44 piles, as under water, averaging 28 feet, running feet	1,232
Square timber put in above water, running feet	10,605
Joists, plank, scantling, and boards, (which call lumber,) feet, board measure	22,869

Of these items I paid, before I learned of the departure from the plans, what was returned to me by the inspector, for putting in square timber under water, 6,645(P) running feet; scantling and boards 2,084(P) feet, board measure; leaving, according to this basis of settlement, to be paid to Vincent & King, for putting in under water of square timber, including the driving of 44 piles, 22,987 running feet, at 15 cents, $3,448 05(9); putting in square timbers above water, 10,605 running foot, $1,060 50(10); framing, fitting, fastening joists, planks, scantling, and boards, (which call lumber,) 20,785 feet, board measure, at $10 per M, $207 85(11).

STONE WORK.

The government plans required, for the whole extension of 480 feet, 844$\frac{4}{5}$ cords.

The inspector returns, as having been put by Vincent & King into their work, in all, 827$\frac{5}{100}$ cords. Of this, I had, before learning of the departure from the government plans, paid for 140(P) cords; and this would leave yet to be paid for, according to this basis of settlement, to Vincent & King, 687$\frac{5}{100}$ cords, at $13 per cord, as per contract price, amounting to $8,936 54(12). All has now been stated for which Vincent & King have received any pay, marked (P), (P), (P). Soon after making the payments to them, as stated, I learned by special inquiry from the inspector that Vincent & King had not driven the piles to stay the four 30 feet cribs which I had supposed they had put in under water; not dreaming even then that they had framed and put in a 120-feet instead of four 30-feet cribs. On learning the condition of things, I immediately notified them through the inspector that I would not pay for any more work, under or above water, that did not conform to the government plans and specifications with which they had been furnished before commencing their work.

This notice was given to them, so the inspector has since informed me. And here is a proper place to say: after the contractors for doing the work (Vincent & King) received the government plans with the bills of materials and specifications, they departed materially from these plans, not only without my authority, but after I learnt of the departure and notified them of the risk they were taking, and especially advised Mr. Vincent in my office to the contrary, they persevered, assuming the risk of, and upon their own responsibility putting in the work upon their own method, using the government materials already furnished for the government plans, and supplying the deficiency this necessitated, themselves, as sub-contractors for executing their method; presuming that I would pay Brooks & Adams for the excess of timber and lumber under

their contract to any amount that might be required to execute the extension upon the method adopted by Vincent & King for putting in the work.

The summing up is as follows:

Debit Vincent & King with item (1)	$29 10
Debit Vincent & King with item (2)	197 27
Debit Vincent & King with item (3)	121 87
Credit Brooks & Adams with item(4)	1,248 84
Credit Vincent & King with item (5)	10 50
Credit Vincent & King with item (6)	512 00
Credit James Loveday with item (7)	118 58
Credit Vincent & King with item (8)	70 50
Credit Vincent & King with item (9)	3,448 05
Credit Vincent & King with item (10)	1,060 50
Credit Vincent & King with item (11)	207 85
Credit Vincent & King with item (12)	8,938 54

The difference between the sum of the positives and the sum of the negatives is $15,267 12, (item 13.)

And this is the sum total that, upon this basis of settlement, the government would yet have to pay and be the owner of materials on hand not used up, costing $436 88.

Now Vincent & King request me to pay the full amount, item (13), the same as if they had put in the work upon the government plan, which, for reasons fully stated, I have refused to do so.

II. Another mode of settlement would be to credit the whole of item (13), and debit Vincent & King with such a sum as will leave a balance in their favor, which would be an equivalent to what the work they have put in is worth to the harbor. I made out upon this basis the sum which I thought should be deducted, and found it to be $7,833 46, which deducted from item (13), left $7,433 66 as a balance to be paid by the United States, and I proposed to pay this provided I should be so authorized by the engineer department, but Vincent & King declined. This would have left the present work put in by them to cost the United States $25,394 69, quite as much, in my opinion, as it is worth, considering that the work complete, according to the government plans would have cost only $33,499 59.

III. Suppose a settlement upon the following basis of allowing for the existing work of Vincent & King what it is worth, toward a proper improvement of the harbor:

1. The existing work, say from end of old pier for about 258 feet of it, may be regarded as good a protection as far as it goes, to the new channel, (should no more careening take place,) as may be desired, though a very bad show for an engineering work.

2. The outer 240 feet of the existing work, nearly all under water and much careened and sunken, affords but little protection to vessels entering in a gale the newly dredged channel, but will, for some considerable time, serve to prevent this channel from again filling with sand; and it will, with the other portion, afford a good breakwater to cover the construction I shall propose to put under its lee on south side of it, to remedy the evil of Vincent & King's bad construction. In the character of a breakwater, therefore, for the future safety of a proper construction, and for protecting the entrance of vessels in a gale, the outer 240 feet of the existing work is certainly worth considerable to the harbor improvement, even though it should careen so as to rest on the diagonal and sink even lower than it now lies.

Therefore, suppose we allow them, for all in the interior portion of 258 feet, the same as if they had followed the government plans. Hence on and for this there would stand to their credit, as returned by the inspector, for putting in 8,887 running feet square timber (including driving 32 piles) under water, at 15 cents $1,333 05
Putting in 4,624 running feet square timber above water, at 10 cents 462 40
Putting in 14,993 feet, board measure, at $10 ..... 149 93
Putting in 309¼ cords stone, at $13 ..... 4,021 33
Furnishing 32 white-oak piles, at $8 ..... 256 00

In regard to the outer 240 feet of their work, I think this is worth to the harbor not more than the stones in it; amounting, by the inspector's return, to 378¼ cords, which, at the contract price of $13, comes to $4,917 25.

Suppose we put this to their credit, we should also place to their credit item (5) and item (8), both amounting to $81.

In this outer part of 240 feet there have been used up of government materials, (ordered by me and put into their hands before I learned of their departure from the government plans,) timber and lumber costing $3,644 80, iron costing $786 17, and piles costing $96; in all, $4,526 97. Suppose we place this to the debit of Vincent & King, and suppose we also put to their debit items (1), (2), (3), amounting to $348 24; and disallow item (4) and item (7), these last having been ordered or furnished by them without my authority. This mode of settlement would leave a balance in their favor of $6,345 76, and the materials on hand to belong to the United States. If to this sum we add $17,898 11, which has already been paid for materials and work, we should have the cost to the United States of the existing work, such as it is, amounting to $24,243 87.

I know of no way under the contract to settle with Vincent & King, except upon one of the three modes now explained in Chapters I, II, III; and to enable me to pay them upon either, I should have to ask for authority from the proper source, and for instructions as to which basis I should make out the vouchers upon, to have them pass to my credit.

The whole is now respectfully submitted for instructions.

I have the honor to be, very respectfully,

T. J. CRAM,
Colonel Engineers, Brevet Major General.

Brevet Major General A. A. HUMPHREYS,
Brigadier General, Chief Engineers U. S. A.,
Headquarters Corps of Engineers.

C 6.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., March 14, 1868.

GENERAL: The appropriation of $25,000, made March 2, 1867, for Erie harbor, was "for extending the pier" and "dredging channel through to outer bar."

In accordance with that requirement the channel in Erie bay should be dredged so as to give it a depth equal to that of the channel leading into the bay from the lake over or through the outer bar; that is, 12 feet or 12½ feet, or whatever the depth may be.

It is represented here by a committee appointed by the city authorities of Erie, that the wants of commerce pressingly need that increase of depth in the inner channel. You will accordingly proceed to execute the work at the earliest day practicable, having due reference to economy as well as to the pressing wants of commerce, and also to the requirements of the appropriation act in regard to contracts.

The dimensions of the improved channel-way, and the manner and order of executing the work, should have reference to affording the earliest facilities to navigation and to the least expenditure requisite to supply its wants, keeping in view the necessity of further expenditure upon the north pier.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Brevet Major General T. J. CRAM,
Colonel of Engineers, Detroit, Michigan.

C 7.

DETROIT, MICHIGAN, *March* 27, 1868.

GENERAL: I have the honor to transmit herewith the proceedings of the board of engineers convened by virtue of Special Orders No. 28, headquarters corps of engineers, March 5, 1868.

I am, general, very respectfully, your obedient servant,

F. HARWOOD,
Capt. Engineers, Brevet Lieut. Col. U. S. A., Recorder.

Brevet Major General A. A. HUMPHREYS,
Chief of Engineers.

Proceedings of a board of engineers convened by virtue of the following order:

[Special Orders No. 28.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., March 5, 1868.

A board of engineers will meet at Detroit, Michigan, on Wednesday, 18th of March, 1868, or as soon thereafter as practicable, to examine into the causes of the careening of the pier at the entrance to the harbor of Erie, Pennsylvania, and the interruption to its completion.

The board will report upon the facts of the case, and will submit its views upon the subject, and also as to the character of the structure suitable for piers at the locality, and the precautions that should be taken in their construction, and the accessories, if any, needed for their security.

The board will also submit its views as to the best method of proceeding with the improvement of the harbor.

After having collected all the information afforded by the engineer office at Detroit, Michigan, in the possession of Colonel and Brevet Major General T. J. Cram, corps of engineers, the board will proceed to Erie, Pennsylvania, and complete the examination at that place.

The report will be made at Erie or Detroit, as the board may find

most advisable, returning to the latter place, if necessary, for that purpose.

The board will be composed of the following members, namely:

Colonel and Brevet Colonel J. N. Macomb, corps of engineers; Lieutenant Colonel and Brevet Major General John Newton, corps of engineers; Lieutenant Colonel and Brevet Brigadier General W. F. Raynolds, corps of engineers; Lieutenant Colonel and Brevet Colonel C. E. Blunt, corps of engineers; Major and Brevet Colonel J. B. Wheeler, corps of engineers. Captain and Brevet Lieutenant Colonel F. Harwood, corps of engineers, will act as recorder.

By command of Brigadier General Humphreys.

THOMAS LINCOLN CASEY,
Major of Engineers and Brevet Colonel U. S. A.

DETROIT, MICHIGAN,
Wednesday, March 18, 1868—10 a. m.

The board met in obedience to the above order.

Present: Colonel and Brevet Colonel J. N. Macomb, corps of engineers; Lieutenant Colonel and Brevet Brigadier General W. F. Raynolds, corps of engineers; Lieutenant Colonel and Brevet Colonel C. E. Blunt, corps of engineers; Major and Brevet Colonel J. B. Wheeler, corps of engineers; Captain and Brevet Lieutenant Colonel F. Harwood, corps of engineers, recorder.—Absent: Lieutenant Colonel and Brevet Major General John Newton, corps of engineers.

The cause of General Newton's absence not known.

The board proceeded to an informal consideration of a sketch and papers, furnished for their information on the subject of the careening of the pier at the entrance of the harbor of Erie, Pennsylvania, by Colonel and Brevet Major General T. J. Cram, corps of engineers, engineer in charge of the work at that place. Awaiting the arrival of the absent member, the board adjourned at 12.30 a. m., to meet in the afternoon of the same day.

DETROIT, MICHIGAN,
March 18, 1868—3 p. m.

The board reassembled. Present all the members, excepting Lieutenant Colonel and Brevet Major General John Newton, corps of engineers, not yet arrived.

The board resumed the informal consideration of papers and sketches connected with the subject of the piers at Erie, Pennsylvania, and at 5 p. m. adjourned until 9 a. m. the following day, March 19, 1868.

DETROIT, MICHIGAN,
March 19, 1868—9 a. m.

The board met in pursuance of adjournment. Present, all the members, including Lieutenant Colonel and Brevet Major General John Newton, corps of engineers, who had been unavoidably detained by railroad detention.

The board then in formal session proceeded to take up, read, and consider, in connection with their appended drawings, the following papers:

A memorandum by Colonel and Brevet Major General T. J. Cram, corps of engineers, reciting the history of the improvement of the harbor of Erie, Pennsylvania, while under his charge.

General Cram's reports on Erie harbor, Pennsylvania, of dates as follows: Report November 12, 1864; annual reports 1865, 1866, 1867; report 1867 on increasing depth of lake harbors, (so much as applied to Erie harbor;) special report, February 28, 1868; engineer department letter of September 12, 1866, directing General Cram to extend north channel pier, Erie harbor, Pennsylvania, 500 feet in crib-work.

All of the above-mentioned papers having been laid before the board for their consideration, by Colonel and Brevet Major General T. J. Cram, corps of engineers, in accordance with the provisions of the order convening the board, after full discussion and the hearing of verbal statements on the matter in question from General Cram, at 1 p. m. the board took a recess until 2.30 p. m. The board then resumed the subject of the careening of the pier at Erie, Pennsylvania, as set forth in General Cram's special report of February 28, 1868, and examined the contract between General Cram and Vincent & King, the contractors for the pier's extension, referring to the detailed plans with explanatory notes attached.

The board also considered General Cram's letters of instruction of various dates to his inspectors at Erie, Pennsylvania, concerning the manner of construction of the pier extension and the circumstances of its careening. After due discussion of the subject, at 4.30 p. m. the board adjourned until 9 a.m. the next day, March 20, 1868.

DETROIT, MICHIGAN,
March 20, 1868—9 a. m.

The board met. Present, all the members.

The board having collected and discussed all the information afforded by the engineer office at Detroit, Michigan, in General Cram's possession, at 10 a. m. adjourned to meet at Erie, Pennsylvania, on Monday, March 23, 1868.

ERIE, PENNSYLVANIA,
March 23, 1868—7.30 p. m.

The board met in pursuance of adjournment, present all the members, and adjourned to visit the careened pier at the entrance of the harbor at 9 a. m. the following day, the 24th.

ERIE, PENNSYLVANIA,
March 24, 1868—9 a. m.

The board met in pursuance of adjournment. Present, all the members, and proceeded to the careened pier at the mouth of the harbor, and after examining it thoroughly, returned to the city. Mr. Vincent, one of the contractors for the construction of the careened pier, was then called before the board, and was subsequently joined by his partner, Mr. King. Mr. Vincent recited the progress of the work, his instructions from General Cram and from Mr. Camp, General Cram's inspector at Erie, Pennsylvania, at the time of the construction of the pier extension, and also his (Mr. Vincent's) understanding of the degree of authority of Mr. Camp as to giving orders to the contractors, and changing details in the plan of the work. Mr. Vincent having concluded his statements, Mr. Camp, formerly inspector at Erie, Pennsylvania, for General Cram, was called, and with him Mr. Dunlap, the contractors' foreman superintending the work. Mr. Dunlap stated his instructions as to the detail of construction, and the manner in which the cribs were actually constructed and filled, and narrated the progress of the careening and settling of the work, and his project for righting it. Being also

an old resident, he likewise related the history of former constructions in the same vicinity. Mr. Camp, formerly inspector of the work of pier extensions at Erie, Pennsylvania, presented to the board his original instructions as to carrying on the work, which were read. He also stated his understanding of his position as inspector of the work, and the extent of his authority, and his recollection of the purport of General Cram's remarks to himself and the contractors, made in May, 1867, concerning the length of the cribs, and the contractors' proposed plan of joining four cribs in one section. He likewise replied to general questions from the board as to the progress of the construction, and dredging in connection with it. Having completed its examination and investigations at Erie, Pennsylvania, the board adjourned at 1 p. m. to meet at Detroit, Michigan, on the following day, March 25, at 2. p. m.

DETROIT, MICHIGAN,
March 25, 1868—2 p. m.

The board met in pursuance of adjournment. Present, all the members.

General Cram was called upon to state to the board what written instructions he had given to his inspector or the contractors at Erie, Pennsylvania, as to the period in the process of construction at which the piles were to be driven and bolted in the corners of the cribs.

To this he replied by referring to his letter-book, from which copious extracts were read; and after further verbal explanations on his part, at 5 p. m. the board adjourned to meet at 9 a. m. the next day, March 26, 1868.

DETROIT, MICHIGAN,
March 26, 1868—9 a. m.

The board met in pursuance of adjournment. Present, all the members.

The board having fully examined into the causes of the careening of the pier at the entrance to the harbor of Erie, Pennsylvania, and the interruption to its completion, after full discussion and mature deliberation have the honor to submit the following report:

The board carefully examined all papers and records in General Cram's possession concerning the work of improvement at Erie harbor, made a personal examination of the pier, and questioned the contractors, Messrs. Vincent & King, their foreman, Mr. Dunlap, and General Cram's inspector, Mr. Camp, concerning the construction and putting in place of the pier.

The board find that a pier 498 feet long was built by Messrs. Vincent & King, extending outward into Lake Erie from the extremity of the old north pier, and in the line of its prolongation.

They find that the framing of the timber, formation of the bottoms of the cribs, bolting, filling with stone, and the line of direction of the pier, conform to the plan, and instructions furnished from time to time by General Cram.

They find that General Cram's plan required the pier to be composed of separate cribs, each to be 30 feet long, 18 feet wide, and 12 feet high, and a continuous superstructure to be built on these to the height of six feet, making the pier 18 feet high from top to bottom. Each crib to have piles driven in the four inside corners and firmly fastened to the crib-work.

They find that the contractors, in constructing the pier, built it in sections of 120 feet long, excepting a short crib 18 feet long, inserted after-

wards, between the old pier and new work to fill up an interval made when the first section was placed. These sections fulfilled all the conditions of General Cram's plan, excepting that the cribs of which they were composed were joined together in a continuous work above the third course from the bottom instead of above the twelfth, as shown in the plan. These sections were successfully placed, sunk in position, and properly filled with stone. They find that 31 stay piles, 17 piles on the north side and 14 on the south, were driven in the corners of the cribs, leaving 37 not driven in the corners of the outer sections.

In September, 1867, a heavy northeast gale caused a serious careening northward, which has been aggravated by subsequent storms, and the board find the present appearance of the pier to be as shown by the drawing herewith attached.

CAUSES OF THE CAREENING OF THE PIER AND THE INTERRUPTION TO ITS COMPLETION.

The board find that the cause of careening seems to have been the washing out of the sand from under the bottom of the pier on the side exposed to the action of the waves of the lake. The cribs of which pier is composed being only 18 feet wide, having the stone ballast confined by the close plank bottom, settled along the north side into the cavity, which the moving waters of the lake excavated into the sand, and as there was no corresponding action of the water to excavate the sand from under the south side of the pier, careening was the consequence. Had the cribs been made of sufficient width, and with openings for the stone ballast to pass through to replace the sand, or had a protection of rip-rap been placed sloping outward from the sides of the pier at the time of filling the same, it is probable that no injurious settling would have occurred to the crib work; in fact, the experience here and at other harbors where the lake bottom is sandy would seem to render it certain that the pier would have been essentially safe, if the above-named precautions had been adopted.

The careening of the pier was so great, from the effect of the September gale, as to effectually suspend all further work toward completing the outer half.

CHARACTER OF STRUCTURE FOR PIERS, AND METHOD OF PROCEEDING WITH THE IMPROVEMENTS.

The board are of opinion that by forming a rip-rap of stone on the north side of the pier, further careening might be prevented; and likewise by partially shifting the ballast, and by cutting a trench with a dredge, close to the channel side of that portion of the pier designed to be preserved, that is, the first 258 feet, the cribs may be brought from their present inclinations into positions more nearly vertical on the sides. The remaining portion of the pier, 240 feet, is unserviceable and cannot be used. The board would recommend that this portion be removed, as no permanent structure can be placed upon this line until all the timber has been taken away. In their opinion, this removal can be effected for a sum not exceeding $4,000.

When this removal has been effected the pier should be extended outwards into the lake, until a depth of not less than 14 feet of water be obtained.

In case this removal cannot be effected, the board would recommend for this portion that a pier be constructed and placed south of and parallel to the present pier, and as close to it as possible, this pier to be

joined to the present one by an angular crib, so as to prevent a shoulder upon which vessels might strike as they come out of the harbor.

The board are of opinion that a structure resting on piles would not be proper for this pier, but that the pier should be composed of separate cribs, not less than 24 feet wide, with grillage bottoms, and the pier terminated with a proper pier-head, with its exposed sides sheath-piled.

The board are of the opinion that the old piers (both north and south) should be repaired, either by replacing the decayed timber, as recommended by General Cram, or, if the foundation is found to be sufficient and the means are available, by permanent stone superstructure.

The old breakwater, connecting the south pier with the main land, should be partially rebuilt to its full height, commencing at both extremities, and the effect carefully observed, to determine the propriety of closing the entire opening.

END OF REPORT.

Having completed its duties, at 4 p. m. the board adjourned *sine die*.

J. W. MACOMB,
Colonel Engineers, Brevet Colonel U. S. A.
JOHN NEWTON,
Lieutenant Colonel Engineers, Brevet Major General U. S. A.
W. F. RAYNOLDS,
Lieutenant Colonel Engineers, Brevet Brigadier General U. S. A.
C. E. BLUNT,
Lieutenant Colonel Engineers, Brevet Colonel U. S. A.
J. B. WHEELER,
Major Engineers, Brevet Colonel U. S. A.
F. HARWOOD,
Captain Engineers, Brevet Lieutenant Colonel U. S. A., Recorder.

C 8.

UNITED STATES ENGINEER OFFICE, DETROIT,
Michigan, April 21, 1868.

SIR: In compliance with your orders of 31st March last, I have the honor to submit the accompanying "plans and estimates in detail" for carrying out the views of the board recently convened, upon Erie harbor. Sketch A shows the "ripraps" proposed by the board on the north side of the careened pier. It also shows the dredging proposed to be done by the board to make a trench on the south side of the interior part of the new extension. It also shows what is recommended by the board to be taken up of the outer part of Vincent & King's work. It also shows the plan and position of the line of the cribs proposed to be put on the south side of this part, "in case the 240 feet outer portion cannot be taken up." A drawing, in elevation, of one of these cribs is marked B, and the plan of the crib is marked C. In case of taking up the outer 240 feet of Vincent & King's work, to a depth of 14 feet below low stage of water, the board recommended an extension by cribs to a depth of 14 feet into the lake on the prolongation of the part of Vincent & King's work which the board recommended to be righted "by shifting the ballast, &c." For this purpose it will require eight cribs 30 feet long, and the method of framing them is sufficiently shown by drawings

B and C, and the sheathing of piles for the pier-head is shown by drawing D.

The pier-head is nothing more than the outer crib, protected by piles to be driven close together, and rip-rapped with stone, the piles to be double-bolted to the end and sides of the cribs. Drawing E shows the cross section of the head and riprap which is to extend across the head and along the sides.

ESTIMATE OF COST.

By the abstract of bids, with a copy of the advertisement attached, it will be seen that, for all recommended by the board in connection with Vincent & King's works, class A, the estimated cost is $7,976 14

This includes item nine, in the advertisement, for taking up the outer 240 feet of Vincent & King's work. Cost of extension, by eight new cribs, 30 by 24 feet, to 14 feet water	15,186 64
Superstructure upon these eight cribs	5,900 60
Cost of sheath-piling and riprapping pier-head	3,458 56
To which add 10 per cent. for contingencies	3,252 19
Total	([a])35,774 13

Comparing this sum with the sum $21,000 or $22,000 set forth as applicable to this work, in orders 2d April, from engineer headquarters, it will be seen that we shall fall short of funds to accomplish all of item ([a]). Foreseeing this, I did not advertise for any new crib work, but confined the advertisement to the operations according to the recommendation of the board upon Vincent & King's work, and interior dredging.

Should the outer 240 feet of their work not be taken up, but a line of piering be put inside of it, as recommended by the board, the estimate is as follows:

Cost of all, except item nine in the advertisement, in reference to Vincent & King's work	$3,821 14
Cost of inner line of eight cribs, (one triangular,) including superstructure	20,423 29
Sheath-piling and riprapping pier-head	2,770 12
Contingencies, ten per cent	2,701 45
Total	([b])29,716 00

Neither will the funds available accomplish item ([b]). Again, to repair the old north and south piers, as recommended by the board, will, according to my estimate in my annual report of 1867, cost ([c])$10,000.

To partially rebuild the old breakwater connecting the south pier with the shore or main land, as recommended by the board, will cost, say ([d])$18,000. (The estimate for rebuilding the whole of this is in that annual report, and amounts to $23,729.)

Having wrought out items ([a]), ([b]), ([c]), ([d]), and herewith presented the plans and details, which I was ordered to do towards carrying out the recommendation of the board, I now pass to reporting upon the subject of the dredging in the inner channel, ordered in letter from headquarters corps of engineers, March 14, 1868.

By the advertisement and abstract of bids herewith sent, it will be

seen that this is ready to be put under contract, Class B having fallen to the same bidders, Denny & Baily, as Class A. The place where the inner dredging is to be done is all fixed, and the amount to be dredged. The sum of $6,000 allotted for this in orders from headquarters corps of engineers, April 2, will give a channel about 150 feet wide, to the prescribed depth 12 to 12½ feet.

The existing contract with Lee & Dunbar for dredging the outer bar, particularly designates the work to be done on it; therefore no dredging in the inner channel could be done under that contract; accordingly I had to advertise for the inner channel.

In respect to the outer bar a good channel, 150 feet wide, straight along by the work, put in by Vincent & King, was dredged out last season, and it is reported officially to me that this channel is now, on the opening of navigation, in excellent condition.

Soon after receiving orders of 2d April, I notified Lee & Dunbar to cease dredging on the outer bar.

As soon as we take up the outer part of Vincent & King's work, which the board recommended to be removed, of course there will be danger of the new channel we have over the outer bar beginning to fill up again; their work, however defective, is a present protection to this new channel.

It will be perceived by the abstract of bids accompanying this report that I am ready to make the contracts for carrying out the ideas of the board as far as we have available means; also for dredging the inner channel. And the articles of agreement will be drawn as soon as I am instructed to do so.

I am, very respectfully, your obedient servant,

T. J. CRAM,
Colonel Engineers, Brevet Major General.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Brig. Gen., Chief of Engineers U. S. Army.

Abstract of bids for doing work at Erie harbor, Pennsylvania.

CLASS A.

No. of bids.	Names and residence of bidders.	ITEM 1.—To take off from the works put in by Vincent & King, with as little injury as possible, the planks, joists, and upper timbers from the north pier, new extension, for an extent, pierwise, of about 200 feet.	ITEM 2.—To take out from the north side of the pier the ballast stone, say 71 cords, more or less, and put the same overboard along the face, placing the stones thus taken out on the natural bed of sand in the shape, all along, of a riprap, 15 feet wide at bottom, and gradually rising from nothing, on the north edge to a height of five feet next to the pier. The length of this riprap, pierwise, will be about 220 feet.	ITEM 3.—To dredge a trench in the sand, close up to the bottom of the pier, on the south side thereof, for a length of 200 feet, and width of 20 feet, and to an average of 15 inches, depth of cutting. There will be about 170 cubic yards of sand to be thus dredged and dumped.	ITEM 4.—To pull up as many of the piles that may be judged to have been driven defectively as may be required to be pulled.	ITEM 5.—To drive as many piles in, and for staying the work, as may be required, say to the number of 60, so that their points shall be not less than 12 feet below the low stage of water.	ITEM 6.—To furnish and put properly in the pier or riprap what additional rubble stone may be required, say 200 cords, more or less.	ITEM 7.—To frame fit fasten in place in the superstructure all timber that may be required upon the work of the inner 600 feet of the said
		33,170 ft., b. m.	71 cords.	200 c. yds.	25 piles.	60 piles.	200 cords.	1,92
		Dollars.	*Dollars.*	*Cents.*	*Dollars.*	*Dollars.*	*Dollars.*	*C*
1	Alonzo Denny, Detroit*	10	3	70	5	5	12	
	D. J. Bailey, Toledo* ..	$331 70	$213 00	$140 00	$125 00	$300 00	$2, 400 00	$2
2	Lee & Dunbar, Erie† ...	10	3	50	10	10	17	1
		$331 70	$213 00	$100 00	$250 00	$600 00	$3, 400 00	$2

* John J. Bagley and John T. Blair, bondsmen. † John Hearn and W. S. Scott, bondsmen.

Abstract of bids for doing work at Erie harbor, Pennsylvania—Continued.

No. of bids.	Names and residence of bidders.	CLASS A.					CLASS B.	
		ITEM 8.—To replace and fasten the joists and covering plank upon this portion of the work in the same manner as before their removal.	ITEM 9.—Remove by dredging, or otherwise, as the contractor may elect, to a uniform depth of 14 feet below the low stage of water, all the outer 240 feet of pier extension of said north pier, so clean and perfectly that there shall be a general level bed, in which bed there shall nothing be left rising or sticking up higher than the horizontal plane, 14 feet below said low stage of water; the stone that may be dredged here to be put into the riprap, or pier, in proper shape, and all the other material that is to be raised to effect the removal to be deposited where the engineer may direct, for the use of the United States.			Cost of class A.	ITEM 1.—To dredge, tow away, and dump the earth raised, at such place as the engineer in charge may direct—the present interior channel of this harbor—at such place, in such direction, to such an extent, width, depth, and manner as the engineer in charge shall direct, to the amount of 16,668 cubic yards, more or less, as the funds already appropriated shall justify. The measurement of the dredging to be made by the engineer in charge, in the natural bed before dredging, upon the data furnished by the survey, under the direction of the Lake Survey in 1865-'66, and the contractor to be paid upon this estimate. The dredging to commence as soon as the legal papers can be executed with the contractor, and all to be completed on or before the 1st of September next, and as much sooner as the engineer in charge may direct.	Total cost of classes A and B.
		10,136 ft., b. m.	190 stone.	75 timber.	6,000 iron.		16,658 cub. yards.	
		Dollars.	*Dollars.*	*Dollars.*	*Cents.*	*Dollars.*	*Cents.*	*Dollars.*
1	Alonzo Denny, Detroit*	8	15	15	3		35	
	D. J. Bailey, Toledo*...	$81 04	$28 50	$1,125 00	$180 00	$7,976 14	$5,830 30	13,806 44
2	Lee & Dunbar, Erie†...	10	.....	37 90	7½		50	
		$101 30	$10 00	$30 00	.....	15,736 00	$8,329 00	24,065 00

*John J. Bagley and John T. Blair, bondsmen. †John Hearn and W. S. Scott, bondsmen.

I certify that this is a true abstract of the original bids.

T. J. CRAM, *Col. Engineers.*

C 9.

UNITED STATES ENGINEER OFFICE,
Detroit, May 8, 1868.

SIR: On the 21st ultimo I forwarded abstract of bids for Erie harbor, upon which Alonzo D. Denny and D. E. Bailey were the lowest. Your letter of the 24th ultimo came, directing me to contract for all advertised for, except item nine, Class A. When I notified Denny and Bailey that the contracts were ready for signature, they declined the award, on the ground that item nine had been exempt. The letter declining is herewith sent. I immediately made out other papers, awarding the contract to Lee & Dunbar, the next lowest, and the only bidders remaining on the abstract. The articles have been signed, and duplicates, together with the bond, are herewith forwarded. I notified Lee & Dunbar that the contract would not be perfectly closed until approved by the proper authority. If, therefore, the contract be approved, please notify at once, and I will order the work to be forthwith commenced. If not approved the work falls through for want of bidders.

I am, very respectfully, your obedient servant,

T. J. CRAM,
Colonel of Engineers, Brevet Major General.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Brig. Gen., Chief of Engineers U. S. Army.

TOLEDO, *April* 29, 1868.

SIR: Item nine (removing old pier at Erie) having been taken from the work of improving Erie harbor, we would respectfully decline the award of the balance of the work.

D. E. BAILEY,
A. D. DENNY.

Major General T. J. CRAM,
Colonel Engineers, Detroit, Michigan.

I certify that the above is a true copy of the original.

T. J. CRAM,
Colonel Engineers, Brevet Major General.

Articles of agreement entered into this thirtieth day of April, eighteen hundred and sixty-eight, between Brevet Major General T. J. Cram, colonel corps of engineers, of the one part, and the firm of Lee & Dunbar, of Erie, in the State of Pennsylvania, of the other part.

This agreement witnesseth, that the said Brevet Major General T. J. Cram, colonel engineers, for and in behalf of the United States of America, and the said firm of Lee & Dunbar, for themselves, their heirs, executors, and administrators, have mutually agreed, and by these presents do mutually covenant and agree, to and with each other, in the manner following, namely: That the said firm of Lee & Dunbar shall do the following prescribed work at Erie harbor, Pennsylvania, at such points as the engineer in charge may direct.

CLASS A.

1. To remove from the work put in by Vincent & King, with as little injury as possible, planks, joists, and upper timber, as much of each as may be required, and pile the same where the engineer in charge may direct, for ten dollars ($10) per thousand feet, board measure, therein contained.

2. To take out from the north side of the new extension of the pier as much of the ballast stones as may be required, and put the same overboard, placing them along that face on the natural bed, in the shape of a riprap 15 feet wide at the base, and gradually rising from nothing on the north edge to a height of five feet next the pier, for three dollars ($3) per cord of 128 cubic feet.

3. To dredge a trench in the sand, close up to the bottom of the pier on the south side thereof, for a length of 200 feet, and width of 20 feet, and to an average of 15 inches depth of cutting, or more if required, for fifty cents (50 c.) per cubic yard.

4. To pull up as many piles, already driven in the work, as may be required, for ten dollars ($10) per pile.

5. To drive as many piles for staying the work as may be required, to such depth that their points may be 12 feet below bottom of water, for ten dollars ($10) per pile.

6. To furnish and put properly in place in the pier or riprap what additional stone may be required, for seventeen dollars ($17) per cord.

7. To frame, fit, and fasten in place in the superstructure all timber that may be required upon the inner 200 feet of said extension, for twelve and a-half cents (12½ c.) per running foot.

8. To replace and fasten the joists and covering planks upon this portion of the work, in the same manner as before they were removed, for ten dollars ($10) per thousand feet, board measure.

CLASS B.

To dredge, tow away and dump the earth raised at such place as the engineer in charge may direct, the present interior channel of this harbor, at such place, in such direction, to such an extent, width, depth, and manner, as the said engineer may direct, for fifty cents (50 c.) per cubic yard; to be measured by the said engineer, in the natural bed before dredging, upon data furnished by the survey under the direction of the lake surveys of 1865–'66.

That all work offered to be done under this contract shall, before being accepted, be subject to a rigid inspection by an inspector appointed on the part of the government; and such as shall not conform to the specifications set forth in this contract shall be rejected.

That the said firm of Lee & Dunbar shall commence to do the work herein specified, if required, on or before the 12th day of May, eighteen hundred and sixty-eight, (1868,) and complete the whole thereof on or before the 1st day of September, eighteen hundred and sixty-eight (1868.)

That payment shall be made when the work contracted for shall have been done and accepted, reserving 10 per cent. from the payment until the whole shall have been completed and accepted.

No member of Congress, officer or agent of the government, or any person employed in the public service, shall be admitted to any share herein, or any benefit which may arise herefrom.

In witness whereof the undersigned have hereunto placed their hands and seals, the day and date first above mentioned.

Executed in quintuplicate.

T. J. CRAM, [SEAL.]
Colonnl Engineers, Brevet Major General.
LEE & DUNBAR. [SEAL.]

Witnesses to General Cram's signature—
MONTGOMERY BACHUS.
HORACE SMITH.

Witnesses to Lee & Dunbar's signatures—
THOMAS WILKINS.
RICHARD F. GAGGIN.

I do solemnly swear that the copy of contract hereto annexed is an exact copy of a contract made by me personally with the firm of Lee & Dunbar; that I made the same fairly, without any benefit or advantage corruptly to said firm or any other person, and that the papers accompanying include all those relating to the said contract, as required by statute in such case made and provided.

T. J. CRAM,
Brevet Major General, Colonel Engineers.

Sworn and subscribed to before me, a justice of the peace for Wayne county, State of Michigan, this 8th day of May, 1868.

PETER B. AUSTIN,
Justice of the Peace.

Bond.

Know all men by these presents, that we, the firm of Lee & Dunbar, of Erie, Pennsylvania, and John Hearn and W. L. Scott, of the same place, are held and firmly bound to the United States of America in the sum of four thousand dollars ($4,000) lawful money of the United States, for which payment, well and truly to be made, we bind ourselves, and each of us, our and each of our heirs, executors, and administrators, for and in the whole, jointly and severally, firmly by these presents. Sealed with our seals, dated the thirtieth day of April, in the year of our Lord eighteen hundred and sixty-eight, (1868.)

The nature of this obligation is such that if the above-bounden firm of Lee & Dunbar and John Hearn and W. L. Scott, their heirs, executors, and administrators, or any of them, shall and do in all things well and truly observe, fulfill, accomplish, and keep all and singular the covenants, conditions, and agreements whatsoever, which, on the part of the firm of Lee & Dunbar and John Hearn and W. L. Scott, their heirs, executors, or administrators, are or ought to be observed, performed, fulfilled, accomplished, and kept, comprised or mentioned in certain articles of agreement, bearing date the thirtieth day of April, eighteen hundred and sixty-eight, (1868,) between Brevet Major General T. J. Cram, colonel corps of engineers, on the part of the United States, and the said firm of Lee & Dunbar, concerning the doing of certain prescribed work at Erie harbor, Pennsylvania, according to the true intent and meaning of said articles of agreement, then the above obligation to be void, otherwise to remain in full force and virtue.

LEE & DUNBAR. [SEAL.]
JOHN HEARN. [SEAL.]
WM. L. SCOTT. [SEAL.]

Witnesses to Lee & Dunbar, also to Hearn and Scott—
W. BREWSTER.
RICHARD F. GAGGIN.

C 10.

UNITED STATES ENGINEER OFFICE,
May 26, 1868.

SIR: In strict conformity with your orders from headquarters corps of engineers, of 11th, 12th, and 16th instant, I advertised anew for Erie harbor separately for the work to remedy the defects in the north pier extension by Vincent & King, and for the dredging of the inner channel, as you will see by the copy of the advertisement attached to the abstract of the bids herewith sent.

Before notice could be sent to-day to bidder number two, William H. Douglass, that he was the lowest for dredging inner channel, (Class B,) I received a telegram from him withdrawing his bid, (32 cents per yard.) The official notice from this office and the bond were just being put in the post office as the telegram was received. The notice and bond, however, have gone forward to him, and on receipt of them he may conclude to abide by his bid. Should he still decline, the next lowest, number five, (Lee & Dunbar,) will accept this dredging (Class B) at their bid, (37½ cents.) And to save time (should Douglass not abide) I shall make out the contract with Lee & Dunbar for Class B, and forward it for approval, and when approved I can have them commence the dredging at once.

Bid number one, William Nicoll, is lowest on Class A. The legal papers with him are being drawn, and will be forwarded for approval, and when approved he will immediately commence.

Very respectfully, your obedient servant,

T. J. CRAM,
Colonel Engineers, Brevet Major General.

Brevet Major General A. A. HUMPHREYS,
Brigadier General, Chief of Engineers U. S. Army.

Abstract of bids for doing work at Erie harbor, Pennsylvania, May 28, 1868.

Number of bids.	Names and residences of bidders.	CLASS A.																CLASS B.*			
		ITEM 1.—To take off from the works put in by Vincent & King, with as little injury as possible, the planks, joists, and upper timbers from the north pier, new extension, for an extent, piecewise, of about 200 feet.		ITEM 2.—To take out from the north side of the pier the ballast stone, say 71 cords, more or less, and put the same overboard along that face, placing the stones thus taken out on the natural bed of sand, in the shape, all along, of a "riprap," 15 feet wide at bottom, and gradually rising from nothing on the north edge to a height of five feet next to the pier. The length of this "riprap," piecewise, will be about 230 feet.		ITEM 3.—To dredge a trench in the sand, close up to the bottom of the pier, on the south side thereof, for a length of 200 feet, and width of 30 feet, and to an average of 15 inches depth of cutting. There will be about 170 cubic yards of sand to be thus dredged and dumped.		ITEM 4.—To pull up as many of the piles that may be judged to have been driven defectively as may be required to be pulled.		ITEM 5.—To drive as many piles in, and for staying the work, as may be required, say to the number of 60, so that their points shall not be less than 12 feet below the low stage of water.		ITEM 6.—To furnish and put properly in the pier, or "riprap," what additional rubble-stone may be required, say 200 cords, more or less.		ITEM 7.—To frame, fit, fasten in place in the superstructure, all timber that may be required upon the work of the inner 200 feet of the said extension of the north pier.		ITEM 8.—To replace and fasten the joists and covering plank upon this portion of the work in the same manner as before their removal.		Total of Class A.		ITEM 1.—To dredge, tow away, and dump the earth raised at such places as the engineer in charge may direct, (the present interior channel of this harbor,) at such place, in such direction, to such an extent, width, depth, and manner, as the engineer in charge shall direct, to the amount of 16,668 cubic yards, more or less, as the funds already appropriated shall justify. The measurement of the dredging to be made by the engineer in charge, in the natural bed before dredging, upon the data furnished by the survey under the direction of the "Lake survey," in 1865–'66, and the contractor to be paid upon this estimate. The dredging to be commenced as soon as the legal papers can be executed with the contractor, and all to be completed on or before the 1st of September next, and as much sooner as the engineer in charge may direct.			
		33,170 ft. b.m.		71 cords.		200 c. yds.		25 piles.		60 piles.		200 cords.		1,920 run'g ft.		10,130 ft. b.m.				16,668 cubic yards.			
		Rate.	Am't.	Rate.	Am't.	Rate.	Am't.	Rate.	Am't.	Rate.	Am't.	Rate.	Am't.	Rate.	Am't.	Rate.	Am't.			Rate.	Am't.		
1	†Wm. Nicholl, Detroit	$10	$331 70	$2 50	$177 50	$0 50	$100	$4 00	$100 00	$3	$180	$12	$2, 400	$0 10	$192 00	$7	$70 91	$3, 552 11		$0 32	$5, 333 76		
2	†W. H. Douglass, Buffalo, N. Y																						
3	§Dan'l E. Bailey and A. D. Denny, Toledo, Detroit	10	331 70	3 00	213 00	45	90	8 00	200 00	5	300	12	2, 400	12	230 40	8	81 04	3, 846 14		45	7, 500 60		
4	‖Patrick Smith, Cleveland	12	398 04	7 00	497 00	60	120	10 00	250 00	6	360	13	2, 600	16	307 20	18	182 34	4, 714 58		44	7, 333 92		
5	¶Lee & Dunbar, Erie	10	331 70	3 00	213 00	50	100	8 50	212 50	8	480	13	2, 600	13½	240 00	8	81 04	4, 258 24		37½	6, 250 50		

* Class B was advertised separately and bid for separately. † Bondsmen, Francis Adams and Jas. H. Jones, Detroit. ‡ Bondsmen, T. B. Gallagher and J. E. Harris, Buffalo; (received telegram from W. H. Douglass withdrawing his bid, before he could be notified that he was the lowest.) § Bondsmen, Thos. Courtwright, Painesville, Ohio, and John J. Bagley, Detroit. ‖ Bondsmen, J. Olrvill and Wm. Quigley, Cleveland. ¶ Bondsmen, Jas. H. Lee and Wm. H. Abell, Buffalo.

T. J. CRAM, *Colonel of Engineers, Brevet Major General.*

C 11.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., May 27, 1868.

MAJOR: In reply to an inquiry from these headquarters, whether there are other localities than Erie where the plan of cribs with close-planked bottoms has been adopted, Brevet Major General Cram, reports "that there is only one other under the recent appropriation, and that is Grand river, where the bottom is sand. overlying clay; and here the cribs have answered the design."

As soon as your duties will permit, you will please have a careful examination and survey made of the harbor at Grand river, with a view to a report upon the condition of the works recently constructed there, viz., the extension of the east pier, and particularly as to the depth of sand overlying the clay, and whether the cribs have settled, and if so, to what extent; whether they are exposed to currents or waves, and if so, whether on both sides or one. You will also examine into the effect of the structure upon the channel, &c.

Funds to enable you to carry out the above instructions will be remitted to you, upon your estimate and requisition, from the appropriation for examinations and surveys of northwestern lakes.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Major W. MCFARLAND,
Corps of Engineers, Erie, Pennsylvania.

APPENDIX D.

UNITED STATES ENGINEER OFFICE,
Buffalo, New York, September 1, 1868.

GENERAL: In accordance with provisions of engineer headquarters' circular, of June 10, 1868, and general regulations on the subject, I have the honor to submit herewith my annual report of progress on the works of harbor improvements under my charge.

BUFFALO HARBOR, NEW YORK.

The work of improvement of this harbor was transferred to me on the 3d of June, 1868, by Brevet Major General T. J. Cram, colonel corps of engineers, in obedience to Special Orders No. 67 from headquarters corps of engineers, dated May 27, 1868.

A general scheme prepared by that officer had been submitted by headquarters to the consideration of a board of engineers assembled at Buffalo, New York, in January, 1868, and was adopted by that board as to its general features. At a subsequent session of the same board, at Detroit, Michigan, in March, 1868, a detailed consideration of the plan of construction of the proposed new breakwater was held, and the result of their deliberations approved.

On relieving General Cram, in charge of the work, I was furnished with a copy of engineer headquarter's instructions, to him, of April 30, 1868, for my information and guidance. By those instructions I was required—

1. To prepare and protect the existing piers.

2. To extend the south pier according to General Cram's plan, as recommended by the board of engineers for Buffalo harbor, and approved by headquarters.

3. To do such dredging as might become necessary between the extension of the south pier and the prolongation of the line of the north pier, to get 14 feet of water.

4. To commence the construction of the new breakwater in the position and with the length proposed by General Cram, as recommended by the board of engineers for Buffalo harbor, and approved by headquarters.

The breakwater to be built according to the plan of construction recommended by the board of engineers for Buffalo harbor, at their session of March 27, 1868, when convened by order of March 11, 1868, from headquarters corps of engineers.

All the works of improvement were to be carried on with the utmost diligence.

The south part of the Erie basin breakwater was not to be removed until authorized from engineer headquarters.

I found the work just about to commence, and up to the close of the fiscal year nothing of importance had been done, beyond making the necessary preparation for the interior harbor works of improvements, and starting the repair of the south United States pier-head.

All the work of improvement of the interior harbor, viz., repairs of north and south United States pier, extension of south United States pier, and the dredging that may become necessary to open the channel of 14 feet depth between the north and south piers, will probably be completed during the year 1868. By letter of June 26, 1868, I advocated the building of as much as possible of the new breakwater, as soon as the repairs of the interior harbor had been attended to, and to the exclusion of the removal of the south part of the Erie basin breakwater, by use of funds from existing appropriations, inquiring if this was the intention of headquarters, to which I received reply in the affirmative; and, accordingly, all funds which have not already been devoted to the improvement of the interior harbor, in accordance with instructions of April 3, 1868, have been reserved for the construction of the projected new breakwater.

Under this provision I propose to build about 900 feet of that work during the winter of 1868–'69 and the ensuing season of fair weather, probably expending all funds now on hand, and completing so much of the work as can be constructed with them by the fall of 1869. In my opinion, as soon as such length of this breakwater shall have been constructed as will afford the requisite lee for vessels inward bound under stress of weather, they will anchor under that lee, in stormy weather, in preference to seeking the inner harbor. Thus the question of the length of extension of the south United States pier and the removal of the southerly end of the Erie basin breakwater will become of minor importance, and the latter more the affair of the State of New York than of the United States. I therefore recommend no deviation at present from the order of proceeding already directed by engineer headquarters.

A careful observation of the efficiency of the extension of the south United States pier now in process of construction may possibly indicate the necessity of further extension, and a further projected removal of the Erie basin breakwater; but as this is a matter of the future, I confine myself, in making requisition for further funds, to an estimate for prospective repairs; to the completion of the new breakwater as at pres-

ent projected, and the opening of the proposed south cut into Buffalo creek.

As regards the latter, I am confident, from due observation, that it would, if effected, much relieve the crowded state of the interior harbor.

BUFFALO SEA-WALL.

This work was also included in the provisions of engineer headquarters' order of May 27, 1868.

No work has been done on it during the past fiscal year, and it accordingly remains in the same state as given in the last annual report, for the work, viz: Total length of wall now built, 5,400 feet; total length of wall and coped, 4,081 feet; total length of wall to be coped, 1,319 feet; total length of wall when finished, 7,050 feet.

I would respectfully recommend that this work be left in its present state until some necessity becomes apparent for its continuation. I see no such necessity just now.

The lake, under the influence of severe gales from the westward, will, it is true, occasionally rise and overflow the land not protected by the sea-wall, but that land is generally firm clay, with but little sand or loose soil overlying. Such little of it as is now swept over by the rise of the lake, under such circumstances, into Buffalo creek, and is not carried out by floods from the interior, must necessarily be removed by dredging. But unless the sea-wall were carried, at great expense, along the beach for about four miles to the southward of the city, until it should reach high ground, it would not avail to prevent the overflow due to the autumnal gales. I therefore do not consider its further construction advisable at present.

If it should be decided to construct the proposed south cut, then I should recommend, in connection with that work, to complete the sea-wall to join with its northerly embankment, thereby protecting from overflow and possible abrasion the intermediate territory and banks of the creek.

DUNKIRK HARBOR.

The work in hand at this harbor, the building of a pier connecting the west sand beach with the beacon crib, was transferred to my charge on the 3d of June, 1868, by virtue of orders from headquarters corps of engineers, dated May 27, 1868. I found the work in a forward state, 4,540 feet of piering having been laid and nearly completed.

The construction of this pier will probably be finished by November of the current year. When completed it will extend from the sand crest of the beach to the beacon crib, a distance of 1,380 feet, and it will form a complete barrier to the wash of sand along the west shore of the bay into the harbor, unless the lake in the fall gales should break through the sand crest and form a permanent beach. This event is not anticipated, but whether it will occur or not can only be determined by watching the inroad of the lake into the beach, as influenced by the construction of the west pier. Should no permanent breach be made during the year 1868, I will be satisfied that the west pier, as at present planned, will answer its purpose of protecting the harbor from the washing in of the sand. Should, however, the fall gales open a channel through the sand around the present west end of the pier, it will become necessary to extend the pier westward about 600 feet to the main bank.

The question of the further improvement of this harbor has been duly and fully discussed in the special reports (with accompanying sketches)

of Brevet Major General T. J. Cram, corps of engineers, of dates May 5th and 15th, 1868; at which time that officer was in charge of the work. Referring to those reports and sketches, it is evident that the necessities of commerce require the construction of the west pier and breakwater "B" which works have already been partly provided for; the west pier as before stated, being in process of construction, and measures being taken in accordance with engineer headquarters' instructions of June 22, 1868, to begin the breakwater.

The amount of appropriation on hand will probably suffice to build about 1,000 feet of that work [see note A] after reserving the necessary funds for contingencies and repairs.

The next subject of importance which presents itself, is the condition of the old outer breakwater. This work as it now stands is an impediment to navigation, being in the course of coasters from ports along the southern shore of the lake. Vessels coming from that direction are observed to round it, and the propellers of the Erie Railway Company have several times touched on the detached sunken cribs in the vicinity of its north-easterly end. Its racked condition, and loss of ballast from the superstructure, render it probable that the autumnal gales of 1868 will carry it away, to below the water's edge. Should this occur, it will become, in heavy weather, a very dangerous, because hidden, impediment.

I therefore strongly advocate its removal at once, to 14 feet depth of water, if it can be done at not too great a cost, defraying the expense out of the existing appropriation. If it is found too expensive to do this, it will become necessary at least to mark its position by buoys, which, however, would be only a partial precaution against casualties. [See note "B."]

This old work being removed, or its position marked, the west pier and new breakwater constructed, it appears to me that the immediate requirements of this harbor will have been satisfied.

It would certainly be very advantageous to provide an inner channel of 14 feet of water from the mouth of the harbor to the Erie railway company's docks, as proposed by General Cram. In fact, the increase of commerce at this place may in a short time necessitate the providing for the free passage of vessels of 13 feet draught. I therefore incorporate General Cram's estimate in my total estimate for completing the improvements. Beyond this, I think nothing more will be needed, unless it shall be found after the completion of the new breakwater that a swell makes from over the site of the proposed additional work "D," in which case that work should be constructed. The shoalness of the water on this site would, however, apparently indicate that the swell would be broken in passing, to such an extent as to render it insignificant.

NOTE A.—At the rates proposed by the lowest responsible bidder, September 10, 1868, 1,500 feet instead of 1,000 feet of the new breakwater can be built.

NOTE B.—Authority received by letter from headquarters corps of engineers, dated August 1, 1868, to incorporate this item in the advertisement for new breakwater, which was done, and nine bids at a cost of less than $10,000 received to remove it, the lowest being $2,179 41.

Abstracts of amounts estimated for the entire and permanent completion of each work, and amount that can be profitably expended during the next fiscal year, July 1, 1868, to June 30, 1869.

Name of work.	Amount estimated for entire and permanent completion.	Amount that can be profitably expended during the next fiscal year.
Improving harbor of Buffalo, New York	$736,205 59	$120,000 00
Improving sea-wall of Buffalo, New York	50,000 00	.....
Improving harbor of Dunkirk, New York	404,500 00	55,000 00

Abstract exemplifying the commerce to which each work contributes, for the fiscal year July 1, 1867, to June 30, 1868.

Name of work.	Number of entrances and clearances, sail and steam vessels.	Total tonnage of all vessels entered and cleared.	Collection district in which the work is situated.	Near what fort, light-house, or port of entry the work is situated.	Amount of money collected at the port during the fiscal year as duties on imports.
Improving harbor, Buffalo, New York. Improving sea-wall, Buffalo, New York.	12,696	5,107,728	Buffalo Creek, New York.	Fort Porter and light-house on pier.	$440,366 31
Improving harbor, Dunkirk, New York.	264	101,457 36	Dunkirk, New York .	Light-house on main land, beacon end to pier.	5,027 93

Abstract of contracts for each work, with names of contractors.

Name of work.	Names of contractors.
Improving harbor, Buffalo, N. Y.....	J. E. & D. E. Bailey, of Toledo, Ohio, and Alonzo D. Denny, of Detroit, Michigan.
Improving harbor, Dunkirk, N. Y....	Alexander McDowell, Hamilton, Ontario, R. Nelson Gere, Syracuse, New York.

Abstract of contract for each class of material or labor for each work.

Name of work.	Name of contractor and what they contract for.
Improving harbor, Buffalo, N. Y.....	J. E. & D. E. Bailey, and Alonzo D. Denny, for furnishing all the material and doing all the work.
Improving harbor of Dunkirk, N. Y..	Alexander McDowell, for furnishing all timber, lumber, and stone, and for doing all the work. R. Nelson Gere, for furnishing all iron materials.

Statement of cash received and expended on account of each work during the fiscal year; amount of appropriation available June 30, 1868, and amount required for the year ending June 30, 1870.

Appropriation.	Amount received.	Amount expended.	Amount available June 30, 1868.	Amount required for the year ending June 30, 1870.
*Improving harbor, Buffalo, N. Y..	$7,000 00	$6,875 18	$193,124 82	$275,000 00
Improving sea-wall, Buffalo, N. Y..	.....	.....	23,751 00	.....
†Improving harbor, Dunkirk, N. Y..	8,500 00	8,333 45	91,666 55	100,000 00

*Of this amount General Cram disbursed $3,084 38, as per the money books turned over to me.
†Of this amount General Cram disbursed $8,329 65, as shown by the money books turned over to me.

Statement of appropriations made for each work.

For what work.	Date of approval of the act making the appropriat'n.	Amount of appropriation.	Total amount appropriated.
Improving harbor, Buffalo, N. Y....	June 23, 1866...	$100,000 00	$200,000 00
	March 2, 1867...	100,000 00	
Improving sea-wall, Buffalo, N. Y..	1864.....	37,500 00	68,500 00
	1866.....	31,000 00	
Improving harbor, Dunkirk, N. Y....	March 2, 1867....	100,000 00	100,000 00

All of which is respectfully submitted. And I am, general, very respectfully, your obedient servant,

F. HARWOOD,
Captain Engineers, and Bvt. Lt. Col. U. S. A.

Major General A. A. HUMPHREYS, *Chief of Engineers,*
Headquarters Corps Engineers, Washington, D. C.

D 1.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., April 16, 1868.

GENERAL: It has been suggested that from the east end of the west pier at the harbor of Dunkirk, New York, a pier be extended in a northerly direction to cover the inner harbor from winds blowing west of north, and to accumulate drifting material on the north side of the west pier, which would otherwise enter the harbor and diminish its capacity.

Your views upon the matter are desired at as early a period as practicable, and likewise a project for the expenditure of the remainder of the appropriation after the completion of the west pier.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Brevet Major General T. J. CRAM,
Colonel of Engineers, Detroit, Michigan.

D 2.

UNITED STATES ENGINEER OFFICE,
Detroit, April 20, 1868.

In compliance with your instructions of the 16th instant, I have
ıor to submit the following views in reference to constructing "a
ım the west end of the west pier, Dunkirk harbor, in a northerly
ın." On my first inspection of this harbor and the line of the old
l west pier, this idea was conveyed to me by the light-house
who, I discovered, had many theories on the subject. He evi-
was not aware that the west pier, when constructed, extended
rdly almost entirely across the low sand ground to the bluff.
act is this: when heavy northwesters occur, a heavy swell rolls
nd the light-house point, and goes *directly against* the line of
n of the old west pier. When the old pier rotted and was
away almost entirely, these swells washed sand, gravel, and
into the western part of the inner harbor, leaving it in the con-
een on the sketch, and probably in time would cause more filling
here is nothing to stop the influx but the present sand ridge on
; prolongation of the line of the old pier. When we began to
the old pier last season we commenced at the point A, just 1,170
n the beacon-light seen on the sketch, and extended eastwardly
0 feet; for, seeing that we should have to extend it from A west-
in all probability, to prevent the sea from washing around to the
d of A into the interior, I had the sand dug away and exposed
en timbers, a few of which were found distinctly marking the
e of the work. I judged that I should have to carry the work
210 feet to the summit of the sand ridge between A and the
At the ridge the depth of the deposit was five feet. It was
by Lieutenant Colonel F. Harwood, who made the examination,
ork extending from A 210 feet to the point B would be suffi-
stop the seas from washing into the west of A. The plan, there-
it is under contract and in operation, is to rebuild upon the line
ld pier for an extent of 1,380 feet. And I had it in contemplation
hat the results would be after constructing so much; and should
ınd necessary either to extend from B still further westwardly,
northwesterly direction, as indicated by the red dotted lines, in
prevent washing material in to the injury of the inner harbor,
amend an extension from B. But until such necessity be shown,
mpleting the work now under contract, I would not recommend
reply to the last part of the order, I had it in contemplation, after
ing the west pier, to expend the residue of the appropriation in
ing, with an additional appropriation, the rebuilding of the old
r, or breakwater.

Very respectfully, your obedient servant,

T. J. CRAM,
Colonel Engineers, Brevet Major General.

et Major General A. A. HUMPHREYS,
Brigadier General, Chief of Engineers U. S. A.

D 3.

UNITED STATES ENGINEER OFFICE,
Detroit, May 5, 1868.

SIR: In reply to the instructions in letter from headquarters corp of engineers April 16, and repeated in letter from the same May 2 requesting my views upon the question of extending a pier in a north erly direction from the east end of the west pier of Dunkirk harbo New York, I have to say, that I did at first misapprehend the question b mistaking "west" for "east." The idea of extending from the west en of west pier had been urged upon me at Dunkirk, and as I did not favo the project I concluded a representation had been made at Washingto advocating this project.

My letter of 21st ultimo can do no harm, although it does not answer th question presented in the letter from the headquarters of the corps o engineers. I will now give my views upon the question of extending pier northerly from the east end of P. (See the sketch.) Suppose w extend one for an extent of 350 to 500 feet in a direction say either du north or between this and a direction 20° west of north which is marked N The stated object of this new idea is "to cover" the inner harbor fro winds "blowing west of north and to accumulate the drifting materi on the north side of the west pier P, which would otherwise enter th harbor and diminish its capacity." Such a construction would certainl cover in some degree the present opening of 350 feet in width to th inner harbor from those winds. Under a heavy blow from west o north, however, a vessel would find it just as difficult to weather th north end of N, to come under its lee, as it now does to enter the inne harbor in the absence of N; and in the heaviest of these blows the vess might be liable (unless N, if constructed, should be extended to a greate length) to miss the entrance to the harbor, and go against the breakwate B, which is on the right of the present opening and which is to be re built. Again, suppose N constructed and no parallel pier to it on th east side; under the heavy northeast blows a vessel coming from the nortl east would meet the reflex wave N, and find it difficult to enter the inne harbor, more so than at present without N.

Under these circumstances it will be inferred that my opinion is tha if N be constructed, it should be at least 750 feet long, so as to serve a an effectual breakwater for vessels to lie under its lee in the outer harbor o that if it be only 350 to 500 feet long, there should be a pier parallel to N starting from the west end of B, and distant from N 350 feet. Now in regard to the assumption "that drifting material accumulated on th north side of the west pier would without N enter the harbor and dimi ish its capacity." I do not see that this would be a necessary result. Wha now goes into the inner harbor through the opening, what went in ther before the whole west pier was rotted and washed away, or what will go i there after we shall have rebuilt P, (which will be completed the presen season,) does not, did not, nor will it fill the inner harbor to any injurio extent. This filling has been since P has been gone. The late Majo Tardy is very explicit on this point, and from my own observations agree with him. He says in his report, December 7, 1866, "the mat rial for this deposit is evidently that which was originally stopped b the west pier P. and which since its destruction has passed over and i rapidly filling the harbor." When we shall have completed P and B there will be no more filling of the interior harbor for many years, ever, as long as P and B are kept up. What may then be washed i

through the opening by the water being driven in will go out again by the outflow which will commence as soon as the gale begins to subside. After P and B are completed it seems to me that we shall be better able to judge from a study of consequent effects whether it will be necessary or advisable to construct N for this purpose.

Nevertheless I have estimated the cost of constructing N based upon prices we are now paying for P and for the work (in 15½* feet water) of cribs and superstructure filled with stone, and 26 feet thick and planked over, and find it to be $83 83 per foot of piering; so that if N should be 750 long it would cost $62,892 50.

This thickness is given to the work because it would be very much exposed, and the bottom is so hard that stay piles could not be driven.

I have the honor to be, very respectfully, your obedient servant,

T. J. CRAM,
Colonel Engineers, Brevet Major General.

Brevet Major General A. A. HUMPHREYS,
Brigadier General, Chief of Engineers U. S. Army.

D 4.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., May 12, 1868.

GENERAL: Your letter of the 5th instant, in reference to the question of extending a pier northerly from the east end of the west pier at Dunkirk, is received.

The chief objection to building this north pier arises from the existence of a rocky ledge having eight feet water, extending across the entrance just inside the two breakwaters. Any vessel entering the harbor from any direction must run in on a southeast course. This course a pier extending towards the north from the east end of the west pier would interfere with.

Can this difficulty be obviated by removing a part of the obstructing ledge?

You will please give your views upon this point, as well as an estimate of the cost of removing as much of the ledge as may be necessary.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Brevet Major General T. J. CRAM,
Colonel of Engineers, Detroit, Michigan.

D 5.

UNITED STATES ENGINEER OFFICE,
Detroit, May 15, 1868.

SIR: Your communication to me of 12th instant has an objection to extending a pier northerly from the east end of the present west pier (P) of the Dunkirk harbor, in that vessels have to enter the harbor on a southeast course, in consequence of the existing ledge of rock underlying at a depth of eight feet the inner harbor; and this being the case, the construction of such a pier would interfere with a vessel on that course. I think this point of objection is well made. To your question "can this difficulty be obviated by removing a part of the obstructing ledge?"

*Referred to lowest stage.

and to the request for my views upon this subject, and for an estimate of the cost of removing as much of the ledge as necessary, I have the honor to reply as follows:

I. In my letter of 5th instant I gave my reasons why if one pier only should be extended from the east end of P, it should be 750 feet long, or that two parallel piers should be constructed, one 400 feet from the east end of P, and the other 350 feet long from the west end of B, both containing the same in length as the single one. The direction "northerly" implies from due north around to 20° west of north for the direction of the pier; further west than that I would not carry it, and I would carry it about to that, because, as we shall see, we shall have the less rock to excavate from the inside, to allow a vessel to safely enter under the protection of P and B, on a course from southeast around almost to southwest; and this I think would afford sea room for the vessel to be brought to safely, before her head would strike the rim of the rock basin into which she would enter. There are seen on the sketch blue dotted lines; the whole space bounded between these would have to be dredged, and the importance of the harbor may probably become such that we ought to aim at a depth of 14 feet for its interior. With these improvements and the completion of P and B, it would be one of refuge, at the same time it would subserve all the business at this port consequent upon its being the terminus of important and extensive railway lines. The rock is talcose slate, disintegrating on exposure to the air above water, but durable as long as kept under water. On my examination of it, I decided to admit this rock as ballast to P and B, for the under-water work, but not above water.

The relevancy of this remark will soon be seen. Mr. Mifflin, my assistant civil engineer, has computed, under my direction, the whole amount to be excavated between the blue lines to a depth of 14 feet, and finds it to be 27,040 cubic yards of sand, gravel, and clay, and 65,044 cubic yards of rock; and I make the following classification of all the different materials to be dredged: 27,040 cubic yards sand, gravel, and clay, that can be readily dredged, and must be wasted; 25,044 cubic yards soft rock that can probably be dredged without blasting, and say one-half wasted; 40,000 cubic yards of rock that cannot be dredged without blasting; but this rock *need not all be wasted* if there be a properly systematized plan of improvement pursued, and money appropriated to carry it steadily on to completion, without those spasmodic actions which in former times attended our lake improvements.

ESTIMATE OF COST.

1. 750 feet piering (whether one or two piers) would cost, including the 10 per cent. contingencies, (see my letter 5th instant)	$62,872 50
2. 27,040 cubic yards sand, gravel, and clay to be excavated, at 40 cents	$10,816 00
3. 25,044 cubic yards soft rock to be excavated without blasting, at $2 75	68,871 00
4. 40,000 cubic yards rock to be excavated, requiring blasting, at $4 50	180,000 00
5. Contingencies on all the excavations 10 per cent	25,969 00
Hence we perceive that the excavation of the basin would cost	285,656 00

dded to the cost of N brings the cost of N and the u to	$348,528 50
st of P and B, according to my last annual report, be	148,584 00
he total cost of P B N and the basin would be...	497,112 50

uite probable some one might with more data suggest a differ- perhaps more convenient, or better shape for the enlargement nterior basin, than bounded by the blue lines, but I doubt if any be planned requiring less dredging. Probably out of all the avated from the basin, 11,076 cords would be fit for crib-ballast, , of course, would belong to the United States.

mount of stone required below water in N is 1,771¾ cords, and 58 cords; that for P has already been contracted for at nearly cord put in the work. After the stone is dredged and deposited cost about $2 per cord to take it from the place of deposit and the cribs. Owing to the necessity of having stone in reserve to tely fill the cribs on being sunk, we could not depend upon the lumping scows for the crib filling. With the number 3,839¾ y to fill the cribs N and B, we could credit the work at $8 per ounting to $30,718, and this would reduce the total cost of all nd the dredging for the basin, to $466,394 50. And as Congress ıly appropriated $100,000 for P and B, we should require an al appropriation of $366,394 50, and have left on hand after ng these works 7,236 cords of stone.

answering the question "what shall be done with the stones?" ıe liberty of bringing to notice two points for the benefit of this hich it would be well to carefully consider before deciding fully and the dredging of the basin. These are the opening of an nnel C, and the construction of an auxiliary breakwater D, seen ketch. By reference to the map of the survey made by Mr. e under the direction of the late Major Tardy, corps of engineers, er, 1866, it will be seen that just east of the east end of B there hat may be called an almost natural "east entrance" to this har- ng 12 to 13 feet water (see Major Tardy's map) just inside the f, (see Lieutenant, now Brevet Brigadier General, Woodruff's map and seven feet water on the summit of the reef as represented by ıdings of Lieutenants T. S. Brown and G. Morell, corps of engi- 1835. And by Major Tardy's map there is shown good depth of 13 feet from C quite up to the railroad company's pier.

istance across this reef at C, I find by General Woodruff's map, feet inside to 12 feet water outside in the lake, is only 550 feet. y evident that whatever changes have been effected—and they en considerable inside the reef in dredging by the railroad com- other causes—no material changes of any consequence have l on the rock of the reef at this "east entrance" C, since Brown's ell's soundings in 1835. Now I assume that the mean depth of in this rock to attain the depth of 13 feet below low stage of ould not exceed 3.25 feet in the width of 350 feet, and for a of 600 feet from 13 feet inside to 13 feet of water outside of the I suppose the worst case, that it is all rock, such an opening for require 25,278 cubic yards of rock excavation; and here it is) remark that a minute survey at C with borings might develop

ore favor able material for a large portion of this excavation until such
ırvey is made; however, I shall estimate the whole as rock that can be
oved and dumped where it may be required for $4 per cubic yard, which
ıld bring the east entrance C to cost, only including 10 per cent. contin-
cies, $111,223 00. We see, therefore, that C would cost less by $174,43
n the basin at the west entrance, or, about $\frac{39}{100}$ as much. The se
suggestion is the auxiliary breakwater D, to extend from the eas
e of C in a southeasterly direction to the mainland. The mea
th of water in which it would stand is $6\frac{67}{100}$ feet, and its lengt
ıld be 1,830 feet. This would completely defend the inner harbo
r B is constructed from the northeast gales; indeed the whole har
with P, B, and D would be entirely locked, having an eastern and
tern entrance, and into one of which a vessel could pass at all time
ler the heaviest gales, and there would be a good current throug
of the entrances, sweeping the inner harbor out through the othe
cross-section of D I would make with a crib-work on the lake fac
'eet wide and seven feet average height, filled with stone, then put o
ıperstructure three feet high, fill it with stones and plank it over; th
of this work would be three to four feet above the surface of the wate
n make a riprap of stone on the inside of the crib-facing, the cri
ng to be well anchored by tree trunks with a foot or two of th
os left on. [For diagram see original.] The width of the riprap o
to be 20 feet and 30 feet on the bottom, and arching on top so as t
at the summit to a height of five feet above the water surface.

ESTIMATE OF COST OF D.

ıppose we had to purchase all the stone at $10 per cord delivered i
work, and other work at the contract prices we are now paying fo
he items would be:

ıber, lumber, and anchor logs	$16,535 3
n bolts, spikes, and nails	3,296 1
or putting in the timber, &c	6,908 3
16 cords of stone in facing and riprap at $10	49,160 0
per cent. contingencies	7,589 9
Total cost of D	83,489 7
dit by the stones that would come out of C (or the basin) o be put into D to the amount of 4,916 cords, at $8	39,328 0
ıving money to be appropriated for D	44,461 7
this add cost of C	111,223 0
	155,684 7
this add cost of P and B	148,584 0
d we should have the cost of P, B, C, and D	304,268 7

'rom this subtract the $100,000 Congress has already appropriate
P and B, and we shall have $204,268 78, for the sum which woul
have to be appropriated to complete P, B, C, and D, a sum less b
2,125 75 than would have yet to be appropriated to complete P, B, N
l the basin.

II. Comparison.—The completion of P and B is necesary, and ha
n decided upon. The question may now be decided whether it i

best not to construct N nor the basin, but construct instead C and D? Or is it best to construct N and the basin, and let all east of B remain as it is? One more remark: should N and the basin prevail, we have seen that we should have 7,236 cords of square stone which could be deposited along the line of D, and thence packed for $200 per cord into a riprap breakwater which, without the vertical facing on the lake side, would cost (10 per cent. for contingencies inclusive) the sum of $15,919 20, and the cost of N, P, B, the basin, and such a riprap, would be $482,313 70, leaving yet to be appropriated $382,313 70.

I have the honor to be, very respectfully, your obedient servant,

T. J. CRAM,
Colonel Engineers, Brevet Major General.

Brevet Major General A. A. HUMPHREYS,
Brigadier General, Chief of Engineers U. S. A.

D 6.

UNITED STATES ENGINEER OFFICE,
Detroit, December 27, 1867.

SIR: I herewith forward my report supplemental to that of June 20, 1867, upon improvement of harbor at Buffalo, New York, with sketch, plans, elevations, drawings in sections, profiles, &c., and printed description and bills of materials in advertisement; the supplement containing estimates based upon bids as per abstract of bids for materials and labor for this improvement.

Respectfully, your obedient servant,

T. J. CRAM,
Colonel Engineers, Brevet Major General.

Brevet Major General A. A. HUMPHREYS,
Brigadier General, Chief of Engineers U. S. A.

Supplement to the report upon the improvement of the harbor at Buffalo, made of date 20th June, 1867, by Brevet Major General T. J. Cram, colonel of engineers.

In chapter 6 of that report, the grand project for the improvement is in items as follows:

1. Repair and protect the existing piers S and N. 2. Extend pier S. 3. Remove some of the south part of the Erie basin breakwater. 4. Construct a new breakwater, B^2. 5. Report upon a navigable ship passage between the lake and Buffalo creek at the south part of the city.

The localities of the various works existing and contemplated, are shown on the accompanying sketch, the existing old works in black, and the proposed new works in red.

The accompanying drawings in plan, elevation and section, together with the printed advertisement, will fully explain all that will be necessary, in details, for comprehending the constructions and modifications proposed.

These drawings, the bills of materials, and amounts of the different kinds of labor required for the execution of the works, are all based

upon surveys, soundings, levelings, borings, &c., which I directed to be made by Brevet Lieutenant Colonel F. Harwood, captain of engineers, (my assistant,) during the past summer, and which were completed in October.

All the different features of the grand project have been before the interested portion of the public since last June; much discussed, commented upon, pondered, and digested. I have not heard a dissenting voice, but all of the intelligent and well-qualified persons who are conversant with this harbor and the navigation of the lakes, and who have expressed their opinions pretty freely upon the subject, approve of the project. Since the surveys have come in to enable me to fully judge the question, I have come to the conclusion that the ship passage, item 5, should form a part of the improvement.

The order of prosecuting the work should be as follows:

First, accomplish Divisions I, II, III, explained in the advertisement, and which embrace items 1, 2, stated in the beginning of this supplement.

Next, accomplish Division IV, explained in the advertisement, which is what the surveys indicate it may be necessary for us to do after 1 and 2 are completed, and which was not referred to in my report of June 20.

Next, accomplish Division VI, explained in the advertisement, and which embraces item 3, in this supplement.

Next, accomplish Division V, explained in the advertisement, and which embraces item 4, in this supplement.

Next, accomplish Division VII, explained in the advertisement, and which embraces item 5, in this supplement.

By strictly following this order in the prosecution of the improvement, we shall make what money we have, very nearly $200,000, accomplish certain steps in the grand project, completing each so as to yield immediate benefit to the harbor, and incur no risk of a stoppage in a step and leaving it incompleted for the want of funds, looking steadily, however, and hopefully to the entire completion of all the divisions, as Congress may make the needful appropriations.

I have no doubt, upon a proper application being soon made, the consent to our removing part of the New York State "Erie Basin Breakwater," Division VI, in the advertisement, will be cheerfully given.

It is upon the foregoing order of doing the work that I have made out the following estimate of the cost, materials and labor, of accomplishing each of the seven divisions, based upon prices in bid No. 5, in the abstract, which is somewhat higher than and next above the lowest, because I am not certain that bidders No. 14, who are generally the lowest, will abide by their bids for all the classes upon which they are the lowest, when we come to the awarding, and being pretty certain that bidders No. 5 will stick to theirs, should No. 14 back out. By taking bid No. 5 to estimate upon, I am sure of being upon the safe side, and having left of the appropriation a handsome margin for contingencies.

ESTIMATE.

Cost of Division I, materials and labor	$19,842 57
Cost of Division II, materials and labor	2,443 07
Cost of Division III, materials and labor	15,138 55
Cost of Division IV, materials and labor	3,600 00
Cost of Division V, materials and labor	25,820 00

of Division VI, materials and labor	$408,683 79
of Division VII, materials and labor	166,698 85
Total	642,226 83
r the lowest responsible bids upon classes A, B, C, D, , for all the Divisions, and supposing the bidders will pt the awards, the total cost is found to be	579,233 97
fference between which and the former total is	62,992 86

difference, should it be realized, and which depends upon the bidders upon classes accepting, would give us a large and ample t for all contingencies.

lso perceive that with the appropriation in hand, we can accom- ivisions I, II, III, IV, costing upon bid No. 5, $66,844 19, and ft over $131,000.

by a further analysis it is easily seen that upon the lowest bids classes, we have money enough already appropriated to accom- ivisions I, II, III, IV, VI, VII, and enough left for inspection ce expenses besides, leaving Division V, the proposed breakwater, e provided for by Congress, making an appropriation of $408,683, ition to what we have in hand for the "entire and permanent tion" of the grand project.

llowing the suggestions in my letter of transmittal of the abstract, ion to drawing the contract with the stated conditions, we could ontract for all the divisions, and have money enough to complete steps but Division V.

would change somewhat the order before stated of prosecuting rks; it would make Division V change places with Division VII, statement.

further seen that I have all along been treating this analysis upon est side for the government, and for the money in hand, having t purpose supposed a backing out when we come to award to the upon classes.

here, and in justice to bidders No. 14, I must add that I have as eived no evidence that they will not promptly accept the awards. e no doubt they will—as soon as I am authorized to notify them contract with them—promptly respond "aye."

uld respectfully draw attention to the following comparison:

y report of June 20 last, certain facts and arguments are given, ich impelled dissent from the former plan, (estimated to cost 00, and upon which Congress had appropriated $200,000,) and dvocated the plan now under consideration; of this the engineer ment expressed itself "inclined to approve," in its letter of last.

ted in that report that the cost of what I proposed "would not t to so much," as the estimate of the cost of the plan I dissented

now seen that the cost does not amount to so much, by somewhat an *eleven hundred thousand dollars*. And I believe the plan which mended was proven conclusively to be a better one for the com- n all its requirements, with stronger works, too, than the plan ed from.

nclusion I have merely to add, that with this supplement all is

forwarded which has been required in engineer department letters of July 9, and November 16, 1867, and not before forwarded.

I have the honor to be, very respectfully, your obedient servant,

T. J. CRAM,
Colonel Engineers, Brevet Major General.

Brevet Major General A. A. HUMPHREYS,
Brigadier General, Chief of Engineers U. S. A., Washington, D. C.

To Contractors.

UNITED STATES ENGINEER OFFICE,
111 *Griswold Street, Detroit, Michigan.*

Sealed proposals in duplicate, written out in the form hereinafter described, will be received by the undersigned, for furnishing materials and doing the work for improving the harbor at Buffalo, New York, until noon of the 25th of November, 1867.

For easy reference and understanding, the improvements are put under the following divisions:

DIVISION I.

Repairs and preservation of slope of old stone revetment around head of south pier, requiring—

36 round piles, 24 to 26 feet long, 12 inches diameter, exclusive of bark at middle, of best quality of white oak.

26 water sills, 6 by 12, in lengths from 10 up to 38 feet—in all 641 running feet.

25 binders, 4 by 8, in lengths 15 to 30 feet—in all 596 running feet.

343 side, end, and tie timbers, 12 by 12, in lengths of 6 up to 30 feet—7,487 running feet.

265 joists, 2½ by 12, in lengths from 6 to 15 feet—6,633 feet, board measure.

332 planks, 2 by 12, in lengths from 18 to 28 feet—15,692 feet, board measure.

In this division the pieces of timber in lengths of 20 feet and under, will amount to 52,534 feet, board measure.

Above 20 to 24 feet, inclusive, will amount to 7,686 feet, board measure.

Above 24 to 38 feet, incusive, will amount to 35,059 feet, board measure.

And only one 38-feet stick, the others not exceeding 30 feet.

142 bars, 1 inch square, drift-bolt iron, 16 feet long—7,526 pounds.

116 nut and screw, 2 washer bolts, 1 inch round iron 20 inches long from inside of head to end of the screw—1,160 pounds.

5 inch wrought spikes, 5-16 diameter—1,084 pounds.

219 cords of rubble stone, to fill to bottom of lop-side timbers.

100 cords of brush in bound bundles of 12 inches in diameter, and 8 to 12 feet in length, to be put under water.

In this old south pier there are several places in which breaches through the outer wall or crust of the masonry have been made, in all amounting to some 3,908 cubic yards of rubble, dry, and cement masonry. These to be repaired by masonry similar to the old work.

It will also require 326 cords of rubble stone to fill in behind the superstructure, so as to bring the revetment of the slope to top of superstructure.

DIVISION II.

Repair and preservation old north pier, requiring—

96 cords of stone, which have fallen out of the outer extremity of the old work, to be raised from under water by dredging, and piled on north or south pier, or on both. Among these stones there will probably be about 123 cubic yards of sand also to be raised and dumped where it will do no harm, and which will be paid for besides paying for dredging the stones; all this dredging to a depth of 14 feet of water, to allow of putting in a new head to this pier, consisting of a crib 25 feet long, 10 feet wide, to be sunk alongside of old pier in 14 feet of water; and another crib 25 feet long, 14 feet wide, to stand in five feet of water, and to be fastened upon the old crib-work. And a superstructure of wood and stone, (to be put on these new cribs,) 25 feet long, 24 feet wide, and 8 feet high; the cribs and superstructure to be filled with stone and the work planked over.

The new head will require for the construction of the crib under water—

4 round piles, not less than 12 inches diameter at middle, 24 feet long—best quality of white oak.

94 side, end, and tie timbers, 12 by 12, of lengths from 10 to 25 feet—in these 1,482 running feet.

8 bottom timbers, 8 by 10, 10 feet long—80 running feet.

4 scantling, 3 by 4, 16 feet long—64 feet, board measure.

16 boards, 1 by 12, 11 feet long—176 feet, board measure.

And for the superstructure above water—

30 side, end, and tie timbers, 12 by 12, in lengths of 24 and 25 feet—in these 735 running feet.

12 joists, 2 by 12, 11¾ feet long—294 feet, board measure.

23 planks, 2 by 12, 24 feet long—1,104 feet, board measure.

40 bars, 1 inch square drift-bolt iron, 16 feet long, for cribs and superstructure—2,120 pounds.

6-inch wrought spikes, 5-16 inches diameter—2 pounds.

5-inch wrought spikes, 5-16 inches diameter—66 pounds.

10-penny cut nails—2½ pounds.

46 cords of stone to fill up to bottom of top timber.

To repair the dry masonry coping of the old pier will require about 14 cubic yards of old stones, from those to be dredged up and to be replaced, as coping, in workmanship as formerly, and as now to be seen in the unimpaired part of this pier.

In this division the timber, in lengths of 20 feet and under, will amount to 6,917 feet, board measure.

Above 20 to 24 feet, inclusive, to 4,320 feet, board measure.

Above 24 to 25 feet, inclusive, to 16,500 feet, board measure.

DIVISION III.

Extension of south pier, commonly called light-house pier.

This extension to be done by sinking eight cribs end to end, none in less than 14 feet of water below the low stage, and posing six of them on a level bed, produced by dredging sand to the amount of 616 cubic yards, each crib in the series to have four stay piles driven, one in each interior corner, and to be filled with stones. Crib No. 1 to be on one side 23, and on the other 33 feet long, making one end oblique to the sides, and 24 feet wide. Cribs Nos. 2, 3, 4, 5, 6, to be 30 feet long, and 24 feet

wide. Cribs Nos. 7 and 8 to be 30 feet long, and 26 feet wide, to stand on natural bed in water from 14 to 15½ feet deep below said stage, and their bottom side timbers to be so shaped as to fit the bed, by making one end deeper than the other, so that the upper side of said timbers shall be horizontal.

Over the cribs and extending back quite even with the center of the light-house, there is to be a superstructure of timber, rising six feet above water, filled with stones to bottom of top timber, and then to be planked over. One side of the superstructure, as it extends back from the crib No. 1, to rest upon the old close row of piles now standing, and the other side to rest upon the old stone revetment. The total length of the superstructure is 318 feet. The portion resting on the crib is 24 feet in length.

The eight cribs require for construction—

572 side, end, and tie timbers, 12 by 12, in lengths from 22 to 23 feet—in these 15,246 running feet.

2 leveling timbers, 10 by 12, 30 feet long, to be hewed to fit slanting bottom—60 running feet.

105 crib bottom-pieces, 8 by 10, in lengths from 15 to 26 feet—2,527 running feet.

12 braces, 8 by 8, 9 feet long—108 running feet.

7 sticks, 6 by 12, from 15 to 26 feet in length, some for water sills, and some for leveling up the work—141 running feet.

4 binders, 4 by 8, in lengths from 10 to 30 feet—73 running feet.

271 crib bottom-boards, 1 by 12, of lengths 11 and 18 feet—4,794 feet, board measure.

23 clamps, 2 by 12, 14 feet long—644 feet, board measure.

31 scantling, 3 by 4, in lengths 12, 22, and 24 feet—688 feet, board measure.

The whole superstructure requires for its construction—

308 side, end, and tie timbers, 12 by 12, of lengths from 5 to 32 feet—in these 6,397 running feet.

6 braces, 8 by 8, 9 feet long—54 running feet.

314 joists and planks, 2 by 12, in lengths 10, 22, 24, and 26 feet—in these 14,316 feet, board measure.

174 joists, 3 by 12, 10 feet long—5,220 feet, board measure.

28 white oak round piles for staying cribs, no less than 12 inches in diameter at middle, excluding bark, of which 20 to be 24, and 8 to be 28 feet long.

330½ bars 1 inch square drift bolt iron, 16 feet long, for cribs and superstructure—17,516 pounds.

17 round inch iron nut and screw, and 2 washers, bolts 22 inches long from inside of head to point of screw—170 pounds.

6-inch wrought spikes, 5-16 diameter—161 pounds.

5-inch wrought spikes, 5-16 diameter—826 pounds.

10-penny cut nails—24 pounds.

669 cords of rubble stone, for cribs and superstructure.

In this division the pieces of timber, in lengths of 20 feet and under, amount to 36,177 feet, board measure.

Above 20 to include 24 feet—110,984 feet, board measure.

Above 24 to include 33 feet—131,907 feet, board measure.

DIVISION IV.

Dredging for channel.

After the work in Divisions I, II, III, shall have been done, it may become necessary to dredge the space between the extension of the south

the prolongation of the line of north pier to obtain a depth of chan- of 14 to 15 feet below the low stage. This will be estimated in cubic ls, and the price for dredging and dumping the same out of the way eep water to be bid for. Our surveys now show about 12,000 cubic ls of this deposit requiring removal.

DIVISION V.

Breakwater to improve the existing harbor and to afford refuge.

his is designed to be about 4,000 feet long, to stand in a straight line hich the average depth of water below low stage is 27 feet; to con- of cribs 50 feet long, placed end to end, made of square timbers. sides of the cribs to rise from the bottom with a batter of $\frac{3}{10}$ so ribs shall be 18 feet wide at the low-water surface, and thence the of the superstructure to rise vertically eight feet above said surface. widths of the cribs at bottom will be from 31½ to 36 feet, according e depths in which they are to stand, the whole work to be filled with e stones up to bottom of top timbers and planked over.

e cribs, 80 in number, will require for their construction 17,610 side, , and brace timbers, 12 by 12, of lengths from 12 to 35 feet, amount-) 453,923 running feet; 4,272 end timbers, 11½ by 12, lengths 18¾ to et, amounting to 116,735 running feet; 160 bottom cross-ties 12, lengths 31½ to 35¾ feet, amounting to 5,415 running feet; 1,760 bottom timbers, 8 by 10, lengths 31½ to 35¾ feet, 59,757 running 640 tie braces 6 by 8, all 18 feet long, 11,520 running feet; 10,264 m boards, 1 by 12, 12 feet long, 123,168 feet board measure; 1,824) and leveling pieces, 2 by 12, lengths 12 to 26 feet, 63,392 feet board ure; 338 scantling, 3 by 4, lengths 10 to 17 feet, 5,090 feet board ure.

e superstructure above said low stage will require for its construc- 4,300 side, end, and tie timbers, 12 by 12, lengths 10 to 30 feet, 0 running feet; 16 corner braces 8 by 8, all 9 feet long, 114 running 2,400 joice 3 by 12, all 10 feet long, 72,000 feet board measure; , covering planks, 2 by 12, all 18 feet long, 132,948 feet board meas- 12,769 bars of one inch square drift bolt-iron, 16 feet long for cribs uperstructure, 676,662 pounds; 5-inch wrought spikes five-sixteenths eter, 13,431 pounds; 6-inch wrought spikes five-sixteenth diameter, pounds; 10-penny cut nails, 1,220 pounds; 19,596 cords rubble for cribs and superstructure.

this division the lengths of timber, 20 feet and under, amount to ,080 feet board measure; above 20 to include 24 feet, 1,890,291 feet l measure; above 24 to include 36 feet, 3,366,134 feet board measure. is division cannot be executed until further appropriation by Con- s for this harbor.

DIVISION VI.

In reference to Erie breakwater.

is part of the improvement consists in removing the south end of lew York State work known as the Erie breakwater, for an extent 2 feet, provided consent can be obtained, and which will be applied uring the next session of the legislature. Therefore the work ad- sed for in this Division, VI, is contingent, and not to be put under act, of course, until said consent be obtained. Nevertheless it is ned to receive proposals for removing that portion of this structure ı our surveys show to consist of a line of timber cribs, 24 feet wide,

filled with rubble stones, and upon which, as part of the foundation and the natural bed of the lake another part, rests a rubble stone work, faced with hammered or cut stone on one side. Around the foot of the work a row of piles has been driven to protect the stones from the action of the surf.

The stone, crib-timbers, and piles to be removed clean to the original bottom. The width at base, including the crib-work on the bottom, is nearly 100 feet, and from the bottom up to the summit of the break-water it is 25 feet. The water around the work to be removed is 12 feet deep.

There are 1,561 cords of stone to be removed from under water, and 630 cords from above water; of which 190 cords are cut stones. All the other are rough rubble. There are also to be removed 8,904 running feet of crib-timbers from under water, and 430 piles, more or less, to be pulled.

Such of the stones, about 2,000 cords, as are unfit for masonry, are by the contractor for the removal to be put (if the consent of the State can be obtained) into the work of repairs and improvements contemplated in Divisions I, III and V, and the stones fit for masonry, piles, and old timbers to be deposited by him at a convenient place to be designated by the engineer in charge.

For each of the Divisions I, II, III, V, VII, the timber and lumber are to be made from good live hard or white pine, or white oak, as specified, and to be truly and squarely sawed to dimensions, free from rotten knots, splits, shakes, wane, or other defects tending to impair durability or strength. Some of the very longest may be delivered in counter-hewed sticks, if more convenient for the contractor, all to be delivered on land at such points as the engineer in charge may direct.

The timber for Divisions I, II, III, all to be delivered by the 31st of July, 1868, and for Divisions V and VII, during the years 1868, 1869, 1870, should Congress make the needful appropriations.

And all the work in Divisions I, II, III, to be completed in the year 1868, and the work in Divisions IV, V, VI, VII, to be completed during the years 1868, 1869, 1870, if the consent to VI be obtained and adequate appropriations be made.

The plans, specifications, drawings, and detail bills of all materials, are to be seen in this office, and may be inspected by any one desiring to bid, between the hours of 12 and 1 o'clock, during the first two weeks in November.

CLASSIFICATION OF MATERIALS AND LABOR—IMPROVING BUFFALO HARBOR—DIVISIONS I, II, III, V, AND VI.

Materials.

CLASS A.

Item 1.—Round piles to be bid for furnishing and delivering, and paid for by the running foot, Divisions I and II.

CLASS B.

Item 1.—All sawed stuff to be bid for furnishing and delivering, and paid for by the M feet, board measure, at one uniform price, whatever may be the lengths, and whether of oak, white or hard pine, for Divisions I, II, III, and V.

CLASS C.

Item 1.—Nut and screw and washer bolts.
Item 2.—Drift bolt iron.
Item 3.—Wrought spikes.
Item 4.—Cut nails, each to be bid for, furnishing and delivering, and paid for by the pound, for Divisions I, II, III, and V.

Labor.

CLASS D.

Item 1.—Preparing and driving piles, to be bid and paid for per pile, Divisions I, II, and III.
Item 2.—Dredging and dumping to place in the cribs in Division III and or other dirt, to be bid and paid for by the cubic yard.
Item 3.—Dredging or raising and piling stone, Division II, to be bid d paid for by the cord.
Item 4.—Dredging and dumping sand or other dirt in Division II, to be d and paid for by the cubic yard.
Item 5.—Framing, fitting, placing, boring, cutting the bolts, bolting, tening and securing cribs or other work under water in place, whether de of sawed or hewn timber, to be bid and paid for upon the lineal t measured in the work, of timber of whatever size so put in the rk, Divisions I, II, III, and V.
Item 6.—Framing, fitting, boring, cutting, iron for bolts, bolting and tening in place superstructure, above low stage of water, to be bid d paid for upon the lineal foot of timber so put in and measured in e work.
Item 7.—Fitting and fastening scantling and boards, gaining and spik- joists, and the fitting, boring, and spiking plank, all to be bid and id for by the M feet, board measure, therein contained in Divisions II, III, and V.
Item 8.—Furnishing and putting all brush in bundles in the work, to bid and paid for by the cord, measured in the work, Division I.
Item 9.—Furnishing and putting in the work rubble stone, to be bid d paid for by the cord, measured in the work, Divisions I, II, III, and V.
Item 10.—Taking from south or north pier the stone to be piled thereon, d putting the same into the work, Divisions I, II, or III, to be bid and id for by the cord.
Item 11.—Removing and depositing the stones which are fit for asonry, Division VI, to be bid and paid for by the cord.
Item 12.—Removing, by dredging or otherwise, stones which are unfit r masonry, Division VI, and depositing them in the works, Divisions I, II, and V, to be bid and paid for by the cord.
Item 13.—Removing all old timber, Division VI, to be bid and paid for the cord.
Item 14.—Pulling old piles, Division VI, to be bid and paid for by the e.

It must not be forgotten that items 11, 12, 13, and 14, are contingent on the consent of the New York legislature.

CLASS E.

Item 1.—All dredging and dumping, Division IV, required between the ttension of south and prolongation of the line of the north pier, to make depth of 14 to 15 feet channel way, to be bid and paid for by the cubic ard of sand or other dirt measured in the bed.

CLASS F.

Items 1, 2.—Repairing breaches of masonry in old south pier by cement and dry stone masonry as good as that of the pier, and relaying coping of north pier where damaged, to be bid for by the cubic yard, the contractor having the privilege of taking the stones for these purposes from any of those not in place and belonging to the United States, he finding mortar at his own expense.

In making proposals the following form is to be strictly followed, prices to be inserted where the blanks occur:

To Brevet Major General T. J. CRAM, *U. S. Corps of Engineers:*

The undersigned will furnish the materials for, and do the work in any or all of the Divisions I, II, III, IV, V, VI, at the option of the United States, as per your advertisement for improving the harbor at Buffalo, at the following prices:

CLASS A.—Item 1, for —— cents per running foot.

CLASS B.—Item 1, for —— dollars per M, board measure.

CLASS C.—Item 1, for —— cents per pound; item 2, for —— cents per pound; item 3, for —— cents per pound; item 4, for —— cents per pound.

CLASS D.—Item 1, for —— dollars per pile; item 2, for —— cents per cubic yard; item 3, for —— dollars per cord; item 4, for —— cents per cubic yard; item 5, for —— cents per running foot; item 6, for —— cents per running foot; item 7, for —— dollars per M, board measure; item 8, for —— dollars per cord; item 9, for —— dollars per cord; item 10, for —— dollars per cord; item 11, for —— dollars per cord; item 12, for —— dollars per cord; item 13, for —— dollars per cord; item 14, for —— dollars per pile.

CLASS E.—Item 1, for —— cents per cubic yard.

CLASS F.—Item 1, for —— dollars per cubic yard, in cement; item 2, for —— dollars per cubic yard, if dry.

[Here the bondsmen's names are signed.] [Here the bidder signs his name and address.]

The bondsmen must be citizens of the United States, and the bidder is to send duplicates of his sealed proposals in the form above given, with two copies of this advertisement, to the undersigned. There may be separate proposals made in the form given, however, for materials and work. Any bid for one item, without bidding for all the items in a class will be rejected. The government reserves the right of rejecting any or all bids, and for all government materials put in possession of a contractor for doing work, he will be held accountable until the materials are used up in the work, and the work accepted; and the government also reserves the right for the engineer to vary the dimensions and amounts of the materials at his option, to suit contingencies that may arise either in plans, construction, or appropriations of Congress by giving the contractor due notice of the change.

DIVISION VII.

This part of the improvement of Buffalo harbor consists in opening a canal 2,820 feet long, and 200 feet wide, from 14 feet water in the lake, to 14 feet water in Buffalo creek, at a site about one and one-eighth mile south of the present south pier, and to a depth of 14 feet below the low water stage. This division, however, is contingent, and requires further

action of Congress in reference to an appropriation for the fullest improvement and completion of Buffalo harbor before being put under contract. Nevertheless a minute survey and estimate having been made for it, separate proposals are invited for furnishing the materials and doing the work in this division which is divided into Sections A, B, C.

Section A, from lake shore line to 14 feet water in the lake, must have two piers, one 1,058 and the other 1,000 feet long, 20 feet wide, five feet above water, which it is proposed to build upon the plan now in successful execution at Cleveland, called the "close pile pier," designed by General Cram, and which the surveys show to be well adapted to the site at Buffalo. This section will require for its construction:

3,320 white oak round piles, not less than 12 inches in diameter at middle, 28 feet long.

140 water sills, 6 by 12, in lengths, 18, 20, and 30 feet, amounting to 4,080 running feet.

140 binders, 4 by 8, in lengths, 18, 20, and 30 feet; 4,080 running feet.

2,066 side, end, and cross timbers, 12 by 12, in lengths of 18 to 25 feet; 4,173 running feet.

12 corner braces, 8 by 8, 9 feet long; 108 running feet.

1,236 joists, 2 by 12, 10 feet long; 24,720 feet, board measure.

1,890 planks, 2 by 12, 20 feet long; 76,000 feet, board measure.

686 nut and screw and one washer bolts, 1-inch round iron, 22 inches long from inside of head to point of screw, in all amounting to 6,860 pounds.

790 bars, 1 inch square, drift-bolt iron, 16 feet long; 41,870 pounds.

Wrought spikes, 5 inches by 5.16; 5,050 pounds.

4,044 cords brush, in bundles well compressed and bound, 18 inches in diameter, and 8¾ feet long, with ends squarely cut off.

1,619 cords rubble stone.

4,936 cubic yards lake dredging clay, for placing the piers.

20,769 cubic yards lake dredging clay, from between the piers.

Section B, from lake shore line to bank of Buffalo creek, across dry land, 1,170 feet, requires—

172,534 cubic yards clay excavation by dredging.

372 white-oak round piles, not less than 12 inches diameter at middle, exclusive of bark, 26 feet long.

372 ditto, about 10 inches diameter at middle, 16 feet long.

2,340 sheet piles, 4 by 12, sawed, white oak, 18 feet long.

124 strings, 5 by 6, sawed, white oak or pine, 20 feet long.

124 water sills, 8 by 9, sawed, white oak or pine, 20 feet long.

124 water sills, 6 by 12, sawed, white oak or pine, 20 feet long.

124 binders, 4 by 6, sawed, white oak or pine, 19 feet long.

124 fenders, 8 by 12, sawed, white oak, 20 feet long.

124 front caps, 12 by 12, sawed, white oak or pine, 20 feet long.

124 rear caps, 8 by 8, sawed, white oak or pine, 19 feet long.

118 front siding, 10 by 12, sawed, white oak or pine, 20 feet long.

118 rear sidings, 8 by 12 sawed, white oak or pine, 20 feet long.

121 front sidings, 10 by 12, sawed, white oak or pine, 18 feet long.

121 rear sidings, 8 by 12, sawed, white oak or pine, 18 feet long.

581 cross-ties, 8 by 10, sawed, white oak or pine, 12 feet long.

371 1-inch round iron nut and screw and 2 washer bolts, 27 inches long, from outside of head to point of screw, 4,081 pounds.

371 ditto, 22 inches long, from outside of head to point of screw, 3,710 pounds.

502 bars, 1-inch square, drift-bolt iron, 16 feet long; 93 bars 14 feet long, and 93 bars 12 feet long; in all 34,616 pounds.

Wrought spikes, 10 by ½ inch, 247 pounds.
Wrought spikes, 8 by ⅝ inch, 2,419 pounds.
Section C, from bank of creek to 14 feet water in the creek, 58(to be dredged to a width of 300 feet at bottom, and with side slo] 2 to 1, 12,384 cubic yards clay, from under water.
The piles in Section A to be driven so their points shall be 2 below low-water stage, and the dirt dredged to be dumped at such as the engineer may direct.
The piles in Section B to be driven on the points, so the points of feet piles shall be 22, the points of the 16 feet piles 14, and those of the piles 18 feet below the low-water stage; and as much of the clay dr as may be required is to be rammed back of and to fill the bank the remainder wasted at such place as the engineer may direct for the dredging, ramming, filling, and wasting the contractor to b upon the cubic yard, measured in the natural bed before being vated for all the sections, A, B, C.

Classification of materials.

DIVISION VII.

CLASS A.

Item 1.—The 28 feet round piles, for Section A.
Item 2.—The 26 feet round piles, for Section B.
Item 3.—The 16 feet round piles, for Section B.

CLASS B.

Item 1.—The sawed stuff, which must be of white oak, for Sect
Item 2.—All sawed stuff, which may be of white pine, hard pi white oak, for Sections A, B.

CLASS C.

Item 1.—Nut and screw bolts with washers.
Item 2.—Square drift-bolt iron.
Item 3.—Spikes.

Classification of labor or work.

CLASS D.

Item 1.—Dredging to place the piers; Section A.
Item 2.—Preparing and driving round piles; Sections A, B.
Item 3.—Preparing, driving, boring, and spiking sheet piles; Sect
Item 4.—Framing, fitting, placing, boring, cutting iron for bolting and fastening sawed timbers; Sections A, B.
Item 5.—Furnishing and delivering in the piers, brush-filling; Sect
Item 6.—Furnishing and delivering in the piers, rubble-stone fi Section A.
Item 7.—Gaining in spiking and fastening the joists, boring and ing in place the covering plank; Section A.

CLASS E.

Item 1.—Dredging from between the piers and dumping; Sect
Item 2.—Dredging, filling behind dikes, dumping and rammi small quantity required in banks and wasting the rest; Section B
Item 3.—Dredging and dumping in Section C.

The following is the form to be strictly followed by the bidder in making his proposals for Division VII; prices to be inserted where the blanks occur:

To Bvt. Maj. General T. J. CRAM, *Corps of Engineers:*

The undersigned will furnish and deliver for Division VII, improvement of Buffalo harbor, as per your advertisement, as follows:

CLASS A.—Item 1, for —— cents per running foot; item 2, for —— cents per running foot; item 3, for —— cents per running foot.

CLASS B.—Item 1, for —— dollars per thousand feet, board measure; item 2, for —— dollars per thousand feet, board measure.

CLASS C.—Item 1, for —— cents per pound; item 2, for —— cents per pound; item 3, for —— cents per pound.

The undersigned will do the work as follows:

CLASS D.—Item 1, for —— cents per cubic yard; item 2, for —— cents per running foot; item 3, for —— cents per sheet pile; item 4, for —— cents per running foot; item 5, for —— dollars per cord; item 6, for —— dollars per cord; item 7, for —— dollars per thousand feet, board measure.

CLASS E.—Item 1, for —— cents per cubic yard; item 2, for —— cents per cubic yard; item 3, for —— cents per cubic yard.

[Here the names of his two bondsmen to be signed.] [Here the bidder signs his name and place of residence.]

The proposals for Division VII to be separate from those for all the other divisions.

The bidder must forward duplicates of his bid, duly dated, signed by himself, and names and residence of his bondsmen stated, and accompanied by a printed copy of this advertisement.

The bondsmen must be citizens of the United States.

There may be separate bids made in the form given, however, for the materials, and for the work. Any proposal for one item in a class, without proposing for all items in that class, will be rejected. The government reserves the right of rejecting any or all bids; and for all government materials put in possession of a contractor for doing work, he will be held accountable until the materials are used up in the work and the work accepted; and the government also reserves the right for the engineer in charge to vary the dimensions and amounts of the materials, at his option, to suit contingencies that may arise, either in plans, construction, or appropriations, by giving the contractor due notice of the change.

T. J. CRAM,
Col. Engineers, Brevet Major General.

D 7.

UNITED STATES ENGINEER OFFICE,
Detroit, December 27, 1867.

SIR: I herewith forward the abstract of bids, with the advertisement, improving the harbor of Buffalo, New York.

For the whole grand project, embracing all the divisions I, II, III, IV, VI, VII, the bids for the entirety (material, labor or work) range follows:

uglass, Gallagher & Clark, Buffalo	$746,500 45
ury D. Dennison, Syracuse	738,936 27

Van Valkenburg, Preston & Jackson, Lockport..... $680,299 30
The Baileys & Denny, Painesville, Ohio..... 642,226 85
Parsons & Holloway, Buffalo..... 586,806 47

The lowest responsible bidder, however, upon each class, A, B, C, D, E, F, materials and work, for the grand project, embracing all the divisions, as per advertisement, I, II, III, IV, V, VI, VII, is as follows:

For class A, bid No. 9, Douglass, Gallagher & Clark, is the lowest, amounting to.....	$263 04	
	16,131 36	
		$16,394 40
For class B, bid No. 14, Parsons & Holloway, is the lowest, amounting to.....	164,651 01	
	13,790 18	
		178,444 19
For class C, bid No. 5, The Baileys & Denny, is the lowest, amounting to.....	35,351 24	
	5,389 99	
		40,741 23
For class D, bid No. 14, Parsons & Holloway, is the lowest, amounting to.....	245,054 73	
	44,168 37	
		289,223 10
For class E, bid No. 14, Parsons & Holloway, is the lowest, amounting to.....	4,200 00	
	39,254 05	
		43,454 05
For class F, bid No. 5, The Baileys & Denny, is the lowest, amounting to.....	10,980 00	
		10,980 00
Total cost.....		579,233 97

Awarding by classes, we see, therefore, (provided none back out from accepting,) the entire cost of the project will be $7,572 50 less than it would be by awarding to the lowest responsible bid for the entirety; and we should have three contractors instead of one. As far as I can learn, the above-named bidders, as well as their named bondsmen, are responsible.

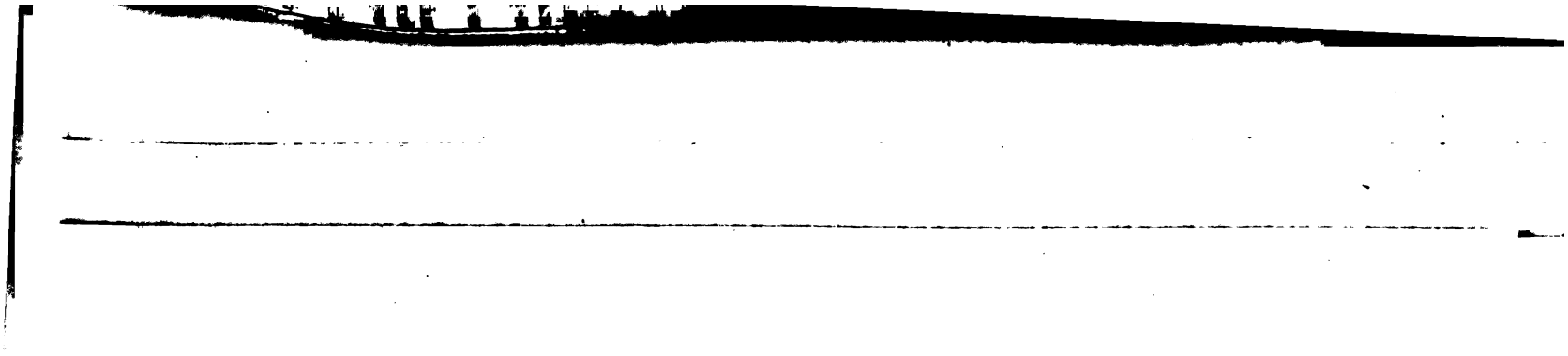
In drawing up the articles of agreement, the three following conditions, in substance, must be inserted:

1. No more materials to be delivered, and no more work to be done than shall be judged necessary by the engineer in charge, to keep the expenditures within the sums appropriated and what may hereafter be appropriated by Congress for this improvement.

2. The order of furnishing materials, and doing the work upon the several divisions, to be prescribed by the engineer in charge.

3. No claim whatever shall be made upon the United States in the shape of indemnity or damage, for stopping the furnishing of materials, or discontinuing the work, which, in the judgment of the engineer in charge, may be found necessary to keep the expenditures within the appropriations.

The opening of the bids, and completing the abstract, have been delayed 20 days in consequence of my having been put upon a court-martial for 45 days.



It is highly important that the contracts should be awarded as soon possible, for now is the season for getting out the timber, &c. I shall ready to act as soon as authority is received.

In case any of the foregoing-named bidders (the lowest for the classes) line when the award is notified to them, of course the award will be de, as heretofore, to the next above, and so on until we find one who l stand to his bid.

Very respectfully, your obedient servant,

T. J. CRAM,
Colonel Engineers, Brevet Major General.

revet Major General A. A. HUMPHREYS,
Chief of Engineers United States Army.

D 8.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 7, 1868.

ENERAL: You are authorized to enter into contracts under the con- ons enumerated in your communication of December 27, 1867, for improvement of the harbor at Buffalo, New York, for the items 1, 2, division IV, and items 3 and 4; that is, for all the work of improve- it as described in your report except that of item 5, the navigable passage between the lake and Buffalo creek, at the south part of city.

he plan denominated item 5 must receive the sanction of Congress re any contract can be entered into for its execution.

ongress has already sanctioned the repair of the two existing piers, lging, &c., and the further improvement by extension of the south , or of either pier, and the construction of a detached breakwater. length to which the south pier should be extended, and the location length of the breakwater, remain to be determined. The authority nter into contracts for materials and labor for these two works is en with the understanding that modifications of the extent of those ictures, and of the depths in which they may be placed, and of their lity, will merely occasion such modifications of materials and labor he officer in charge of the works will be authorized to make under contracts proposed.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

he contracts must be awarded to the lowest responsible bidder for h class of material, and each class of labor, as specified in your adver- ment. The advantage of one contractor for the whole work is loubtedly great, but the law is explicit and positive, and does not e the matter to the discretion of the executive.

A. A. HUMPHREYS,
Brigadier General of Engineers, &c.

revet Major General T. J. CRAM,
Colonel of Engineers, Detroit, Michigan.

D 9.

UNITED STATES ENGINEER CFFICE,
Buffalo, N. Y., January 24, 1868.

GENERAL: I have the honor to transmit herewith the proceedings of the board of engineers convened by virtue of special orders Nos. 4 and 5, headquarters corps of engineers.

I also return by mail the papers and maps furnished for the use of that board, as follows: A manuscript copy of Captain Williams's report, made in 1839; a manuscript copy of the report of the board of engineers, made in 1845; two tracings which exhibit the location of the works, pier, and breakwater proposed and recommended in these reports respectively; a copy of Ex. Doc. 56, parts 1 and 2, containing the report of the late Major Tardy, recommending the plan proposed by Captain Williams in 1839; the engraved map of Buffalo harbor, and the engraved map of Lake Erie.

I am, very respectfully, your obedient servant,

F. HARWOOD,
Capt. Eng., Bvt. Lt. Col. U. S. A., Rec. Board Eng'rs.

Brevet Major General A. A. HUMPHREYS,
Chief of Engineers, Headquarters Corps of Engineers,
Washington, D. C.

Proceedings of a board of engineers convened at Buffalo, New York, by virtue of the following orders:.

[Special Orders No. 4.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 7, 1868.

I. A board of engineers for the consideration of the improvement of the harbor at Buffalo, New York, and the recommendation of a plan or plans for that purpose, is hereby constituted, and will meet at that city on Wednesday, the 22d instant, or as soon thereafter as practicable.

II. The board will be composed of the following officers, viz: Colonel and Brevet Major General T. J. Cram, corps of engineers; Colonel and Brevet Colonel J. N. Macomb, corps of engineers; Lieutenant Colonel and Brevet Major General J. Newton, corps of engineers; Lieutenant Colonel and Brevet Brigadier General W. F. Raynolds, corps of engineers; Lieutenant Colonel and Brevet Colonel C. E. Blunt, corps of engineers; Captain and Brevet Lieutenant Colonel F. Harwood, corps of engineers, recorder.

By command of Brigadier General Humphreys.

THOS. LINCOLN CASEY,
Major of Engineers and Brevet Colonel U. S. A.

[Special Orders No. 5.—Extract.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, January 9, 1868.

I. Special Order No. 4, dated January 7, 1868, is hereby amended by adding the name of Major and Brevet Colonel J. D. Wheeler, corps of

ngineers, to the list of members of the board of engineers for consider-ıg a plan or plans for the improvement of the harbor at Buffalo, New ·ork.

II. In addition to the consideration of a plan or plans for the improve-ıent of the harbor of Buffalo, New York, the board of engineers will lso report upon the character of the works required for a harbor of efuge at New Buffalo, Lake Michigan, and submit a plan therefor.

* * * * * * *

By command of Brigadier General Humphreys.

THOS. LINCOLN CASEY,
Major of Engineers and Brevet Colonel U. S. A.

UNITED STATES ENGINEER OFFICE, BUFFALO, N. Y.,
January 22, 1868.—10.15 a. m.

The board met in pursuance of the above orders.

Present: Colonel and Brevet Major General T. J. Cram, corps of ngineers; Colonel and Brevet Colonel J. N. Macomb, corps of en-ineers; Lieutenant Colonel and Brevet Major General J. Newton, corps f engineers; Lieutenant Colonel and Brevet Brigadier General W. F. Raynolds, corps of engineers; Lieutenant Colonel and Brevet Colonel C. E. Blunt, corps of engineers; Major and Brevet Colonel J. B. Wheeler, corps of engineers; Captain and Brevet Lieutenant Colonel F. Harwood, corps of engineers, recorder.

The orders convening the board were read, together with the follow-ng letters:

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 10, 1868.

GENERAL: You are requested to lay before the board of engineers directed to assemble at Buffalo, New York, on the 22d instant, of which you are the senior officer, all maps, plans, reports, or other papers in your possession, that may be necessary or important to a full investigation of the question of a plan or plans for the improvement of the harbor at that place.

Such information bearing upon the subject as may be in the possession of these headquarters will be transmitted to the recorder of the board.

By command of Brigadier General Humphreys.

Very respectfully, your obedient servant,

J. C. WOODRUFF,
Brevet Brigadier General U. S. A.

Colonel and Brevet Major General T. J. CRAM,
Corps of Engineers, Detroit, Michigan.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 18, 1868.

COLONEL: The following is a list of copies of reports and maps trans-mitted by mail this day for the use of the board of engineers which will meet in Buffalo on the 22d of January, for the consideration of the pro-jects of improvement of the harbor, namely:

A manuscript copy of Captain Williams's report, made in 1839.

A manuscript copy of the report of the board of engineers made in 1845.

Two tracings which exhibit the location of the works, pier and break-water, proposed and recommended in these reports respectively.

A copy of Ex. Doc. 56, parts 1 and 2, containing the report of the late Major Tardy, recommending the plan proposed by Captain Williams in 1839.

The engraved map of Buffalo harbor and the engraved map of Lake Erie.

By command of Brigadier General Humphreys.

Very respectfully, your obedient servant,

J. C. WOODRUFF,
Lt. Col. of Engineers, Brevet Brig. General U. S. A.

Captain and Brevet Lieut. Col. F. HARWOOD,
Corps of Engs., Recorder of Board of Engineers, &c., Buffalo, N. Y.

The board then took up the subject of the improvement of Buffalo harbor, and proceeded to the reading of the documents specified in the foregoing letter, in their order, and the consideration of the maps in connection with them. Upon concluding this reading the board took up the report of Colonel and Brevet Major General T. J. Cram, corps of engineers, upon the improvement of Buffalo harbor, which was read, and pending the reading of which, at 3 p. m., the board adjourned until 9 a. m. the next day, January 23, 1868.

UNITED STATES ENGINEER OFFICE,
Buffalo, New York, January 23, 1868—9 a. m.

The board met in pursuance of adjournment; present all the members

The board concluded the reading of General Cram's report upon the improvement of Buffalo harbor. After full consideration of General Cram's plan and general discussion of the subject of the improvement of Buffalo harbor, the board, after maturely considering the several projects submitted to their deliberation, viz., those of Captain Williams topographical engineers, (1839,) of the board of 1845, of Brevet Major Tardy, (1866,) and of Brevet Major General T. J. Cram, the present engineer in charge, have the honor to submit the following report:

The project of Captain Williams with which that of Brevet Major Tardy is nearly identical, consists essentially in extending the present south United States pier considerably beyond its existing limits, and in the erection of a breakwater to the northward of the pier.

This project, as it appears to the board, is deficient in the essential qualifications of permitting a safe entrance to the shelter of the breakwater, or to the interior harbor, or of affording a good holding ground.

The plan of the board of 1845 may be discussed at the same time with that of Brevet Major General Cram, with which a strong similarity in all essential points is found to exist. The plan of General Cram, however, contains in addition all the repairs or modifications necessary to be made to existing works.

The board approves the recommendation of the engineer in charge, to repair the end of the existing light-house pier, to extend it to a distance of about 300 feet, to repair the north pier, to remove a portion of the south end of the Erie canal basin breakwater, constructed under the authority of the State of New York, and to dredge the entrance of the harbor, to allow a draught of 15 feet at average low water of the season of navigation.

The position of the breakwater, as designed by the engineer in charge to the southward of the entrance of the harbor, is considered to afford a good shelter and anchorage under it, and to cover effectually the entrance to the harbor.

direction of the line of the breakwater, which the board under-
to be designed in the line of the littoral currents upon which the
nsists, is approved.
construction of the breakwater of crib-work filled with rubble
hould conform to principles already laid down by the board of
ır similar localities, as to dimensions of cross-section and length
ı.
ıpper inlet or canal proposed to afford a direct entrance from the
the upper or southern portion of the inner harbor, (which is the
creek,) thus giving an additional ingress and egress, is considered
ıut to the inner harbor, and whenever it is made, will add largely
convenience of commerce.

tenant Colonel and Brevet Brigadier General W. F. Raynolds,
f engineers, submitted to the board for incorporation as a part of
ırt on the improvement of Buffalo harbor the following paragraph:

ard, in submitting this report, wish to be understood as having considered only the
r the improvement of the existing harbor of Buffalo.
er a harbor can be constructed for that portion of the city bordering on the Niagara
nown as Black Rock,) which may at the same time serve the purposes of general
e, has not been discussed, the data for such discussion not having been before the

paragraph, after due deliberation and full discussion, was rejected
following vote: affirmative, 1; negative, 5.
board then proceeded to the discussion of the character of the
required for a harbor of refuge at New Buffalo, Lake Michigan,
g which, at 3 p. m., the board adjourned until 9 a. m. January 24,

UNITED STATES ENGINEER OFFICE,
Buffalo, New York, January 24, 1868—9 a. m.

board met in pursuance of adjournment, and resuming the con-
ion of the harbor of New Buffalo, Lake Michigan, have the honor
nit the following report:

board has considered the subject of a plan for the improvement
harbor of New Buffalo, Lake Michigan. The plan is given in
ın the report of the Secretary of War of February 10, 1858, com-
ıting the report of Lieutenant Colonel J. D. Graham for the year

identical with the plan presented by Brevet Colonel J. B. Wheeler,
of engineers, has been partially carried into execution, and by him
nended to be abandoned.
board, in submitting this plan of improvement for this harbor, feel
l to report that in their opinion the attempt to improve the harbor
be abandoned, and that no further expenditure should be made,
ɔinciding on this point with the views expressed by Brevet Colonel
Wheeler.
considerations which have brought the board to this conclusion
following: the great cost of the required improvement, and the
expenditure necessary to preserve it. The cost of the work
ing to the estimates, at the present contract prices, will be about
00. The annual expenditure necessary to preserve it may be
d by observing the action of the sand, that has changed the outlet
Galien river full 2,100 feet to the southwest of where it was in

ı annual expenditure for preservation cannot be estimated at less
$10,000 per annum, and without this the entrance would choke up,

as there is no local commerce or business of any kind at this place, at present, the interests of which would insure its being kept open.

The want of a local commerce and decay of business of the place leaves us to discuss its merits alone as a harbor of refuge.

Harbors of refuge are important and necessary on Lake Michigan. But the board think that the nearness of Michigan City harbor on one side, St. Joseph harbor on the other, and the number of harbors existing on the same side of the lake with this one, all at the present time being improved by the United States, justify them in saying that it is doubtful whether a harbor of refuge is necessary at this place, and certainly not so much so as to justify any large expenditure of money for that purpose.

Having completed its duties, at 10 a. m. the board adjourned *sine die*.

T. J. CRAM,
Col. of Engineers and Bvt. Major Gen.
J. N. MACOMB,
Col. of Engineers and Bvt. Col. U. S. A.
W. F. RAYNOLDS,
Lieut. Col. of Engineers and Bvt. Brig. Gen.
JOHN NEWTON,
Lieut. Col. of Engineers and Bvt. Major Gen.
J. B. WHEELER,
Major of Engineers and Bvt. Col. U. S. A.
C. E. BLUNT,
Lieut. Col. of Engineers and Bvt. Col.
F. HARWOOD,
Capt. of Engineers and Bvt. Lieut. Col. U. S. A., Recorder.

I have signed the above report with the distinct understanding that the board were not called upon by their instructions to discuss the subject of a change in the locality of the harbor of Buffalo, New York. I am not satisfied that the Niagara river cannot be used both for local purposes and as a harbor of refuge.

W. F. RAYNOLDS,
Lieut. Col. of Engineers and Bvt. Brig. General.

D 10.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., February 5, 1868.

GENERAL: The board of engineers which met at Buffalo on the 23d ultimo, in obedience to Special Orders No. 4 from these headquarters, having recommended that the "construction of the breakwater of crib-work filled in with rubble stone should conform to principles already laid down by the board of 1854 (1853 ?) for similar localities as to dimensions of cross-sections and length of cribs," you will please transmit such a modification of the plans and estimates submitted by you in your supplemental report of December 27, 1867, upon the improvement of Buffalo harbor, as will make this breakwater conform to the requirements of the board.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Brevet Major General T. J. CRAM,
Colonel of Engineers, Detroit, Michigan.

D 11.

UNITED STATES ENGINEER OFFICE,
Detroit, March 5, 1868.

SIR: Paragraph 1359, Revised Regulations of 1861, permits a "dissenting member of a board to present his own memoir," &c. I avail myself of this to dissent from a very few particulars in the report of the board recently convened at Buffalo, upon plans for that harbor, in respect to the cross-section of a breakwater. The rules laid down by the board of 1853 were not in *these particulars* known to me at the time of our session, nor were they before our board; and all the rules which were presented did correspond essentially with the cross-section I had planned and submitted to our board. I am satisfied that if our board had been furnished or known all the rules laid down by the board of 1853, with a view of applying them to a breakwater construction for Buffalo harbor at the site for which I had planned, we should unanimously have rejected all I have presented as objectionable in the accompanying memoir.

Be this as it may, I submit this memoir, in which you will perceive I have complied with your instructions of 5th February last to the fullest extent, giving besides the benefit of the results of much labor in comparing one cross-section with another, to enable the department to decide which cross-section shall be adopted. I respectfully request a decision as soon as may be, so that I may complete the necessary bills of materials for the contractors.

Very respectfully, your obedient servant,

T. J. CRAM,
Colonel of Engineers, Brevet Major General.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Brig. Gen., Chief of Engineers U. S. A.

Memoir of Brevet Major General T. J. Cram, colonel corps of engineers, submitted to headquarters corps of engineers, March 6, 1868,

Upon the construction of a breakwater in Buffalo harbor, containing the modifications of the plans and estimates submitted by him December 27, 1867, as required in letter from headquarters corps of engineers, February 5, 1868, so as to make the breakwater conform to the principles already laid down by the board of engineers of 1853. This memoir also contains the dissent of General Cram to some particulars of the rules of the board of 1853, and explains that the board assembled at Buffalo 2d January, 1868, had not before them the particulars of the rules of the board of 1853 General Cram dissents from. Upon the fourth, fifth, sixth, and seventh rules, made by the board of engineers April 27, 1853, for their application to a breakwater at Buffalo, I shall fully comment, and give my reasons for disagreeing; also for disagreeing to some extent with the board recently assembled at Buffalo in its recommendation upon the cross-section of the breakwater, if the latter board meant, which I think it did not, to give a literal indorsement of all the particulars in the above quoted rules. Fourth rule: "Average width ought at least to equal their total height from the foundation to the platform." Does the "foundation" here spoken of mean the natural bed of the lake, whether sand, clay, or rock, upon which the breakwater is to be posed? To fix an absolute relation of height to breadth, without regard to depth of

water, the nature of the natural bed, or measure of the force of impact, tending to overturn, translate, or rupture the structure, in my opinion, evinces a want of practical experience in these questions. But the board may not have meant in their application of "foundation" the natural bed.

A foundation may be and is generally artificial, and may rise within a few feet or even to the surface of the water to serve as a foundation base for the superstructure. In the latter sense of "foundation" I should agree with the board, and will illustrate as follows:

Suppose, as is the case at Buffalo, a natural bed of clay, and water 25 to 29½ feet deep, and we put in a foundation of cribs filled with stone, rising to within five feet, or even to the surface of the water, [for diagram see original,] then the average width of the superstructure, which is to perform the office of a breakwater, should be "at least equal to the height from the foundation to the platform," as by rule four; and I will add that it ought to be as much wider as will give weight or insertion of filling enough to effectually resist overturning or being moved in translation or ruptured by the force of the impact of wave or ice against it.

So much for the width, and now for the height of the superstructure above the foundation.

This height should be sufficient to receive the wave in its greatest height, and break it before it rolls over the top of the structure.

In the site for the Buffalo breakwater this should not be less than eight feet; there are many places, however, on the lakes where five feet would be ample for this purpose.

And in this consists my disagreement with that board's fifth rule: "That the platform or deck ought to rise five feet above high-water level of the lake."

This absolute fixing of the height at five feet is what I object to; had the rule said at *least* five feet for the breakwater I would not have objected.

At Buffalo the platform of the breakwater should be at least seven feet above ordinary high, and eight feet above ordinary low-water level. The highest waves there, with the latter height of superstructure, according to my experience, would be effectually broken before rolling over to disturb materially the tranquillity of the water on the lee side.

The cross section of the foundation should fill certain practicable conditions—

1. Of such figures as to throw the common centre of gravity of the foundation and superstructure low down.

2. Of such lines for its sides as will enable us with simplicity, and effectually to tie the superstructure down to the foundation, so as to make the under water and above water parts inseparable by the action of a force against the mass.

3. The figure of the section should be such that the crib can be easily floated in a position of stable equilibrium, from the place where it is framed out of the harbor, and sunk where it is to stand.

This implies symmetry of parts on both sides of the vertical line passing through the common centre of gravity.

4. The walls of the crib constituting the foundation should rise in such a manner in regard to angle with the horizon that the weight of the walls of the superstructure may be as much as possible transmitted directly to the walls of the crib, and not bear upon its cross-ties at points inside its walls. Again, the walls should rise in such manner that the rubble-stone filling which must be thrown or dropped in will assume a position bearing well against the sides of the walls.

ıe width of the base of the foundation should not be unnecessarily
or it would require splicing of ties and bottom timbers to make
ıng enough, which would be very expensive and produce unneces-
st of construction.

e are practicable axioms, which any one acquainted with putting
work will at once acknowledge. And I would not go to the
of quoting them here, but for the bearing they have upon the
ıt issue.

ixth rule of that board is, "that the side exposed to the waves
o be vertical from top to bottom."

this mean from top to bottom of the wave? If it does, I should
ect to acquiesce, though it is not supported by any assignable good

But if it means from top of the structure down to the bed of
e, I disagree for strong reasons soon to be explained. Another
n the sixth rule of that board is, "that the sheltered side ought
ertical from the platform to five or six feet below the low-water
ınd thence downward it ought to have a slope or batter in grades
-third to the *natural foundation.*" "*Natural foundation*" here evi-
means the natural bed of the lake. The board, in fixing an abso-
easure of the batter, could not have been guided by any practi-
experience in framing cribs of this shape. Sketch at the right
page five, corresponds to the sixth rule. Let us make the vertical
ext the heaviest action of the sea; also the ends of the crib with
h square timbers. The opposite sides, battering one-third, will, I
require timbers to be $12\frac{659}{1000}$-inch square to bring the faces of its
imbers in the same inclined plane.

could get no mill to saw timber to this dimension, nor could we,
ıt great trouble and expense, get them hewed. But we could make
e side and end timbers 12 inches square, battering the least exposed
one-third by simply stepping these timbers of four inches in tread,
en, Fig. No. 1, on the sheet of drawings. But then comes the prac-
le difficulty in framing the dovetails of the ends of the ties into
ide timbers. I have had models made with a view of testing the
ıitude of this difficulty, and find the framing to be complicated,
iring a compound dovetail, costing three times as much work, and
not as good as when we incline the timbers, to make the batter,
ing their faces in the same plane. There is also another very serious
:tion to stepping the timbers; for when we come up to within five
of the top of the crib, we must bolt upon the inner surfaces of these
ed timbers tie braces, which are essential to hold the superstructure
l to the under water work. The side timbers being in steps, the tie
s would only fay against the corners of these side timbers, giving
aring sufficient to allow of firm bolting. But suppose these two
icable difficulties overcome, the form of the crib, such as the rules
at board require, supposing their "foundation" meant natural bed,
aving symmetry of figure on either side of the vertical axis passing
gh its centre of gravity, would give rise to difficulty in floating out
l sinking it in place; and unless buoyed up on one side, it would
ıd one corner would hang so low in the water as to ground, rend-
us unable to float the crib out of the harbor.

s form for the cross-section has incompatibilities in it, and if
pted to be executed would lead to great expense and embarrass-

re make battered sides of 12-inch square timbers, then the verti-
le and ends will have to be made of timbers of such dimensions in
ections as are never sawed or hewed; again, in order to comply

with the rule 4th, the crib, as well as the superstructure, must be made so broad as to necessitate long spliced end and bottom timbers; also, the superstructure would be so wide as to involve that very objectionable feature of great amount of wooden material above water to rot, and thus enhance proportionably the cost of the subsequent repairs, besides an unnecessary first cost.

Supposing, however, that board meant by its rule "that the part exposed to the waves ought to be vertical from top to bottom," (of the waves,) and that they meant five feet as least height of superstructure.

I have drawn Fig. 2 in a shape to come within their rules. This obviates the objection I raised on the score of common centre of gravity, but involves all the other objections applicable to Fig. 1.

I now present a practicable construction, Fig. 3, involving no incompatibilities of principles.

Make the end timbers of the crib, from its bottom up to within five feet of low-water surface, 11 inches by 12 inches, and also the side timbers of the crib, and side and end timbers above that height, of the superstructure; also, all cross-ties 12 by 12. Make the side most exposed, also the side least exposed, vertical down to "the bottom of the wave," thence to the natural bed on a batter, (to be determined, not assumed, as the board did,) and also incline the timbers of the battered sides so their faces shall be in the same plane instead of stepping them, and assume for the width of the superstructure 24 feet. Now, from these data, adopting the board's fourth rule for the average width, whether we suppose their "foundation" means the natural bed or the artificial one, there results by calculation 4.7958″ for the batter in 11 inches vertical rise, and 44⅔ feet for breadth of base of cross-section. Such a cross-section would be relieved of all the objections of Figs. 1 and 2, except that of splicing timber, and, perhaps, unnecessary first cost, and having more timber to rot in superstructure than would be necessary. Fig. 4 is a cross section, obviating all objections, and in several points would be stronger than Fig. 3. Fig. 4 has its foundation crib rising with battered sides to the low-water level, the batter being 3.333, which gives the end timbers of the crib 11½ by 12, and all the others 12 by 12; but on the most exposed side it does not present a vertical face to the entire wave. To insist upon this verticality to the extent that board does, is a rule, in my opinion, without any good reason to sustain it. The question now arises, which of these cross-sections will be sufficiently stable when constructed?

This is a question of comparison of forces which I am prepared, having made some requisite experiments, to discuss. The natural bed upon which the structure is to rest has been determined, by borings, to be such as to afford great security, in reference to stability, for the breakwater throughout.

From the report of a board of engineers (General Swift, Colonel Kearney, and Major Turnbull) assembled at Buffalo in April, 1845, for the consideration of plans for this harbor, and which involved the construction of a breakwater, I obtained valuable data for my present purposes.

The waves, under the heaviest winds, in that harbor do not exceed, in the estimation of that board, 10 feet in height from the trough to the summit. (See representation of the wave, Fig. 3 and Fig. 4.) Hence, the most exposed sides of the breakwater upon which they impinge is only five feet below and five feet above low-water stage, or six feet above and four feet below low-water stage, and therefore the surface of the side against which they act is only 10 feet in vertical width. Now the force of these waves is not percussive, like that of a trip-hammer; it is

ore like pressures increasing and then decreasing as the wave
ıp and recedes; and I treat the subject by taking the point
ation of the resultant of these pressures during the storm to be
wo-thirds feet below the upper limit of the surface pressed. (See
ınd 4, where the arrows show the point of application of the
t.) The same board give us the greatest velocity of the waves
15 miles per hour, and estimate the force in the direction of the
; 10½ tons to a foot running of the breakwater.
erbourg breakwater, however, the greatest wave runs not to
13 feet high from trough to summit, and exerts a force of only
ıd a quarter tons upon each square yard of surface pressed.
he wave force at Cherbourg must be to that of Buffalo as 13 is
ıich will make the force in the direction of the wave at Buffalo
s upon the square yard pressed. Each crib being 50 feet long,
vertical width pressed only 10 feet, we shall have pressed by
e 55.5 square yards, or the whole crib pressed by a force of 310
, dividing by 50, the pressing force will be 6.192 tons to the foot
of the breakwater. Now this pressure, in the heaviest gales
which we are providing, is exerted obliquely to the face of the
ın angle of 74°. [For diagram see original.] Decompose this
wo components—one, *p*, parallel and the other, P, perpendicular
rce of the breakwater—and we shall find P equal to 5.96 tons
ch running foot of the breakwater. The effects of P are a ten-
turn the breakwater over, around a hinge which is the hori-
dge of the bottom side timber of the crib passing through C, and
the crib and its superstructure a motion of translation in the
ı of P. The moment of the turning force referred to the hinge
ssed by 28 × 5.96.
his is to be counteracted by the weight of the crib in water, and
superstructure in air above, acting in a vertical line passing
the common center of gravity, when all are filled with stone and
l over.
ollowing table, which I have constructed upon experiments made
re, exhibits the data we need to compute the relative capacities
breakwater constructed with the cross-sections—Figs. 1, 2, 3,
to resist being overturned at the site in question; also, the com-
of the resistance of each with the effort to overturn it. I might
ı here a valuable fact, developed in my experiments, viz: that
thern white pine weighs, when water-soaked, more than our hard
he former weighing 39¾ pounds, while the latter weighs only 32¼
to the cubic foot. Besides the tendency of P to overturn, it has
ated that its other effect is tending to give the structure a motion
slation in the direction of P. The breakwater, standing upon a
ttom into which it will settle a little with its grillage bottom,
slide under the action of this force, nor can the force rupture or
e the superstructure, it is so firmly bolted; and, in Figs. 3 and 4,
ıgly tied with the timber tie-braces to the foundation crib.
so much opposed to adopting a cross-section requiring so much
of timbers, difficulty in framing and sinking, and needless cost
l and Fig. 2, that I should wish, should Fig. 3 or 4 be repudiated,
nt another plan that may reconcile all probable differences of
should any exist after a full consideration of this memoir, and
would require only the simplest mode of splicing the ties, and
mbers of such dimensions as are usually sawed in the mills.

Table of weights and buoyant efforts for a 50-foot crib of breakwater, with 50-foot s structure, and moments of forces to overturn and resist.

	CROSS-SECTION OF THE STRUCTURE.			
	1.	2.	3.	4.
Timber under water—				
Cubic feet	10,029.75	9,682.5	9,170.75	8,
Weight in air.....tons..	199.34	192.44	182.27	
Timber above water—				
Cubic feet	2,372	2,111	1,796	
Weight in air.....tons..	47.14	41.96	35.70	
Iron—				
In crib .....cubic feet..	21.59	21.36	20.80	
In superstructure .....cubic feet..	4.09	3.99	3.88	
Difference in weight between iron and the wood it displaces...tons..	5.62	5.54	5.40	
Rubble stone under water—				
Cubic feet	46,682	43,534	41,250	
Weight when submerged.....tons..	1,187.47	1,107.40	1,049.30	
Rubble stone above water—				
Cubic feet	11,143	10,552	7,044	
Weight in air.....tons..	497.63	470.10	313.81	
Sum of all the forces acting vertically downward .....tons..	1,337.22	1,817.44	1,586.48	1,
Buoyant effort of water acting vertically upward.....tons..	313.43	302.58	286.59	
Resultant acting vertically downward of 50-foot breakwater.....tons..	1,623.79	1,514.86	1,299.89	
Force acting vertically downward of 1 running foot of breakwater....tons..	32.476	30.297	25.998	
Measure of moment of force of 1 running foot of breakwater to resist overturning	32.476×25.6= 911.60	30.297×24= 727.13	25.998×22.44= 583.40	19.41 349.
Measure of moment of force upon 1 running foot of breakwater tending to overturn it	5.96×28= 166.88	5.96×28= 166.88	5.96×28= 166.88	5.9 1
Represent by 1 the measure of moment to overturn 1 running foot of breakwater, the measure of moment to resist will be	5,463	4,357	3,512	
Relative cost of the breakwater upon these different plans	$666,154 92	$543,594 72	$498,594 48	$46

NOTE.—It is a fit place here to present some of the results of the experiments upon which this ta been constructed.

1. The white pine which we expect to use for the Buffalo breakwater weighs, green or water-soak pounds per cubic foot in the air.

2. The rubble stone, (the black rock,) weighs while submerged in water 50.875 pounds per cubic they will naturally pack.

3. The same stone weighs in the air, with what resistance it will absorb, 89.100 pounds per cubic they will naturally pack.

4. The bolts, spikes, nails, &c., weigh 477 pounds per cubic solid foot. The buoyant effort of th upon the crib, with or without the bolts and spikes being inserted, as my rule is to bore before bo spiking; consequently there is displaced as much wood in bulk as the iron will occupy; hence, in th the difference between the weights of the iron and of the same bulk of wood displaced enters into th Again, the buoyant effort of the water upon the stone, when submerged, is allowed for by simply us weight of the stone, while submerged in the water, as is seen in the table.

Another force, consisting in floating ice acting upon the breakw demands consideration. Its thickness in this harbor is 12 to 15 in Soon after the northeast winds in the spring it generally breaks up, ing become very tender and brittle, into small masses and escapes the river.

Observe, the northeast winds give the ice a motion, if any, dir away from the exposed side of the breakwater, and this law of b ing up is so invariable that we need not apprehend danger from force to the structure.

Should the anomaly occur of breaking up, however, under a s west wind, blowing violently, the ice might then be forced agains breakwater, but, in my opinion, with no greater effect than woul owing to the velocity of the waves propelling it, if as great. The inju effect would be to cut and abrade the timbers more than a liabil

rturn the structure. In piers acted upon by floating ice, of which I e witnessed several, I have always observed the pier itself is then ered so as to be entirely hidden by an enormous load of ice, which ls vastly to the inertia of the structure, and even defends it from an ading action. I doubt not that for the Buffalo breakwater, should it r be constructed, a similar result will be realized; and it should be erved that a sheet of ice would probably exist at the same time on inner side of the breakwater, affording quite as much inertia in aid he breakwater as the force of ice on the other side would exert against if not more. Should the floating ice be found after construction to the timbers, a sheet of two to three-inch plank can be spiked on, ending, however, not more than two to three feet below the lowest -water level; it would be a useless expenditure to extend it down to natural bed, as directed in ninth rule of the board of 1853. The rd of 1845 discuss the effect of an *acre* of ice in motion, with a velocity three feet per second, (nearly two miles per hour,) impinging against reakwater, and estimate that every two feet front of the cake of an e would exert a pressure of 27.11 tons against each foot front of the ucture.

Did the board mean that the direction of the impact is perpendicular the force of the breakwater? But, as our proposed breakwater would re no such position to receive such an impact, nor could it with any ssibility occur, it is not worth while to borrow trouble on this suppo- ion.

Piers at other places on the lake have been constructed and withstood pressure of floating ice without being cut away or overturned, where, ave no hesitation in saying, the danger has been as great from this use as it will ever be at Buffalo.

It seems to me that a breakwater, (Fig. 4,) the same as I presented in supplemental report on this harbor, forwarded December 27, last, er being demonstrated to have more than double the resistance to the ce acting upon it, should experience no opposition. I should not, how- er, object to Fig. 3, but for its requiring splicing of timbers and cost- g so much more.

I have the honor to be, very respectfully, your obedient servant,

T. J. CRAM,

Colonel Engineers, Brevet Major General.

Brevet Major General A. A. HUMPHREYS,

Chief of Engineers U. S. A., Washington, D. C.

D 12.

BUFFALO, NEW YORK, *March* 31, 1868.

GENERAL: I have the honor to inclose herewith the proceedings of e board of engineers, reconvened by virtue of engineer headquarter's ecial Orders No. 31, March 11, 1868.

I have also the honor to return herewith the official copies of the Jan- ry proceedings of the same board, and General Cram's memoir of rch, 1868, which were forwarded to me from engineer headquarters the use of the board.

I am, general, very respectfully, your obedient servant,

F. HARWOOD,

Capt. Engineers, Brt. Lieut. Col. U. S. A., Recorder of the Board.

Brevet Major General A. A. HUMPHREYS,

Chief of Engineers.

Proceedings of a board of engineers reconvened by virtue of the following order:

[Special Orders No. 31.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., March 11, 1868.

The board of engineers constituted by Special Orders Nos. 4 and 5, dated January 7 and 9, 1868, will reconvene at Detroit, Michigan, as soon as the board of engineers, constituted by Special Orders No. 28, has completed its investigations into the causes of the injury, &c., of the pier at the entrance to the harbor of Erie, Pennsylvania, to take into consideration the letter and memoir of Colonel and Brevet Major General T. J. Cram, corps of engineers, dated March 5, 1868, in which he suggests a cross-section of the breakwater at the Buffalo, New York, as a substitute for that unanimously recommended by the board in its report, dated January 24, 1868.

The board will reconsider the subject and submit its views, together with a drawing of a section of the breakwater 100 feet in length, in plan and elevation, longitudinal and cross-section, bill of materials, and estimate of cost of construction of the section.

By command of Brigadier General Humphreys.

THOMAS LINCOLN CASEY,
Major of Engineers and Brevet Colonel U. S. A.

DETROIT, MICHIGAN,
March 27, 1868—9.30 a. m.

The board reconvened in obedience to the above order.

Present: Colonel and Brevet Major General T. J. Cram, corps of engineers; Colonel and Brevet Colonel J. N. Macomb, corps of engineers; Lieutenant Colonel and Brevet Major General John Newton, corps of engineers; Lieutenant Colonel and Brevet Brigadier General W. F. Raynolds, corps of engineers; Lieutenant Colonel and Brevet Colonel C. E. Blunt, corps of engineers; Major and Brevet Colonel J. B. Wheeler, corps of engineers; Captain and Brevet Lieutenant Colonel F. Harwood, corps of engineers, recorder of the board.

The order reconvening the board was read, and official copies of their proceedings of January, 1868, and General Cram's memoir of March 5, 1868, were laid before the board, they having been sent to the recorder from engineer headquarters for that purpose. General Cram's memoir was read and considered. The board reconsidering its proceedings of January, 1868, proceeded to vote upon the following questions, viz:

In applying its recommendations made at Buffalo, that the dimensions of the cross-sections and length of cribs of the proposed breakwater should conform to principles of the board of 1853, (by error, recorded 1854,) does the board mean—

1. That the total height from the foundation to the platform, as specified in rule four of that board, (1853,) should be measured from the bottom of the lake?

Which was decided in the affirmative, by vote as follows: Ayes, 5; nay, 1.

2. That the height of the platform should be five feet above highest known water?

Which was decided unanimously in the affirmative.

3. That the most exposed side should be vertical from top of superstructure to bottom of lake?

Which was decided in the affirmative by vote, as follows: Ayes, 5; nay, 1.

4. That the least exposed side for a detached breakwater in deep water, as at Buffalo, should be vertical from the top to five or six feet below low-water level, and thence downward should have a slope of three perpendicular to one base?

Which was decided unanimously in the negative.

The board then proceeded to take up and vote upon cross-sections 1, 2, 3, and 4, as shown and discussed in General Cram's memoir of March 5, 1868, the question being, Will the board adopt such cross-section discussed in General Cram's memoir of March 5, 1868, and drawn in strict conformity to the rules of the board of 1853, as the cross-section for the breakwater at Buffalo, New York? Which cross-sections, being severally voted upon, were each, in succession, unanimously rejected.

A plan and sections were then presented for the consideration of the board, to which General Cram proceeded to state his objections in detail. After a full consideration of these objections the board proceeded to vote upon the following question:

Will the board adopt a rectangular cross-section, with a uniform width of 34 feet, framed and constructed as in the drawings herewith presented, representing a cross-section for the mean depth of water along the proposed site?

Which was decided in the affirmative by the following vote: Ayes, 5; nays, 1.

The board then took a recess until 2.30 p. m. At 2.30 p. m. the board reassembled, and having maturely reconsidered the subject of the cross-section of the breakwater at Buffalo, New York, and duly discussed the memoir of General Cram, dated March 5, 1868, have the honor to submit their views in the following report:

The board have duly considered the letter and memoir of General Cram to the Chief of Engineers, dated March 5, 1868, with the accompanying drawings, and have examined the model of the breakwater in his office. They have examined the photographic drawings of cribs constructed by Colonel Graham, and have discussed the rules laid down by the board of engineers of 1853, for constructing breakwaters, piers, &c., the lakes.

The board do not recommend the construction of this work with the ss-sections discussed by General Cram in his memoir with drawings l model, and herewith attach a drawing showing the plan and elevaı of a section 100 feet in length, with longitudinal and cross-sections ier; also a bill of materials and estimate of the cost of construction. he board, in the month of January, 1868, recommended a breakwater ıe "general dimensions" proposed by the board of 1853, (written, by ake, 1854.)

fter a thorough examination of these rules, laying down the principles nstruction, this board, while agreeing to them, do not conceive that are necessarily to be strictly applied in literal detail. The cross-on of the breakwater now proposed is similar to that of the break-r proposed for Burlington, Vermont. It varies from that suggested ıe board of 1853, in having its sides vertical instead of having a slope utter, as suggested by them, for the sheltered side.

ıe details of the construction of this breakwater are nearly identical those of Colonel Graham. The cross-section proposed is rectangular,

34 feet base, and a total height varying from 29 to 37 feet, the top being placed five feet above the high water of 1838, the highest water known.

In the opinion of the board, the breakwater thus constructed will have ample stability and capability of resisting any destructive force, whether of the waves or ice, that it may be exposed to.

In presenting this cross-section, differing, as it does slightly, from the rules laid down by the board of 1853, this board feel it due to the subject, particularly after their indorsement of the principles laid down in those rules, to give their reason for such deviation.

The fourth rule, requiring the average width to be equal to the total height from the foundation to the platform, in the opinion of the board, may be modified for depths of 30 feet and upwards. At the south end, where, on General Cram's chart, the depth is 29½ feet, or, by reference to the high water of 1838, adopted as the standard by the board, about 32 feet, the rule of the board of 1853 would require a width of at least 37 feet instead of 34 feet, which is prescribed in the drawings herewith attached, as the uniform width of the proposed breakwater. The inertia of a mass, such as a crib in 32 feet depth of water, 50 feet long, 34 feet wide, and 37 feet high, and its consequent resistance against an effort to overturn it, is already much superior to the strength of the crib-work which binds the mass together.

In the opinion of the board, likewise, the proposed breakwater, situated in water too deep to allow the wave to break, is not exposed to the impact of water having the motion of translation due to a broken wave; and it follows that the sole necessity was to impose such reasonable width upon the cross-section as might be sufficient to counteract a tendency to careen, arising from the unequal resistance of the bottom of the lake, or a wash of the materials of which it is composed.

The seventh rule, which prescribes a slope to the inner face of piers, &c., from a point five feet below the water level, is likewise departed from. The effect of such slope is to throw the center of gravity nearer to the outer line of the breakwater and to cause an unequal settlement, while, as already shown for structures placed in deep water, there is not sufficient thrust from seaward due to waves to compensate and overcome such tendency.

Alluding to the 14th rule, the board is of opinion that the superstructure should not be put on the cribs until the latter have had sufficient time allowed them to settle and take a permanent bed. That part above the water may be continuous work, or as shown in the drawing, and the length of each crib should not be less than 50 feet.

With these remarks the board respectfully submit the drawings, bill of materials, and estimate of cost, as required by the Chief of Engineers.

Having finished its duties, the board, at 5.15 p. m., adjourned *sine die*.

J. N. MACOMB,
Colonel of Engineers, Brevet Colonel U. S. A.
JOHN NEWTON,
Lieutenant Colonel of Engineers, Brevet Major General.
W. F. RAYNOLDS,
Lieutenant Colonel of Engineers, Brevet Brigadier General.
C. E. BLUNT,
Lieutenant Colonel of Engineers, Brevet Colonel.
J. B. WHEELER,
Major of Engineers, Brevet Colonel.

I respectfully dissent from the majority of the board in the following points: In the shape of the figure of the cross-section; in the size of

cross-section of some of the timbers; in the size of the drift-bolt iron, in the practical method of combining the timbers. In all other pects I agree with the majority, and will present a memoir, as soon can make it, upon the points of my dissent.

T. J. CRAM,
Colonel of Engineers, Brevet Major General.

'. HARWOOD,
Capt. Engineers, Bvt. Lieut. Col. U. S. A., Recorder of the Board.

Bill of materials and estimated cost for one crib.

406 cubic feet of 12-inch square timber, at 25 cents	$2,851 50
80 feet (board measure) for decking, 1,500 feet (board measure) for sheathing; 5,580 feet, at $25	139 50
335 pounds 1¼-inch square wrought-iron bolts, at 5 cents	716 75
pounds wrought-iron spikes, at 7 cents	24 50
50 cubic yards rubble stone, at $2	3,500 00
871 cubic feet framing, at 15 cents	1,780 65
ntingencies of 10 per cent	901 30
Cost of one crib of 50 feet	9,914 20
st of one section of 100 feet	19,828,40

Official.]

F. HARWOOD,
Captain Engineers, Brevet Lieutenant Colonel U. S. A.,
Recorder of the Board.

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timate of cost, using prices now contracted for by General Cram, for this work.

406 cubic feet of 12-inch square timber, at 24 cents	$2,737 44
80 feet (board measure) plank, at $20	111 60
335 pounds 1¼-inch square wrought-iron bolts, at 3⅞ cents	555 58
pounds wrought-iron spikes, at 5½ cents	19 25
50 cubic yards rubble stone, at $1 50	2,625 00
871 cubic feet framing, at 12 cents	1,424 52
ntingencies of 10 per cent	747 40
Cost of one crib of 50 feet	8,220 79
st of one section of 100 feet	$16,441 58

Official.]

F. HARWOOD,
Captain Engineers, Brevet Lieutenant Colonel U. S. A.,
Recorder of the Board.

D 13.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., April 3, 1868.

GENERAL: The amount on hand for the improvement of Buffalo harbor, and such sum as may be appropriated for it at the present session of Congress, will be applied as follows:

1. To repair and protect the existing piers.
2. To extend the south pier according to your plan, as recommended by the board of engineers for Buffalo harbor, and approved here.
3. To the dredging that may become necessary between the extension of the south pier and prolongation of the line of the north pier.
4. To the construction of the breakwater in the position and with the length proposed by you, as recommended by the board of engineers for Buffalo harbor, and approved here.

The breakwater will be built according to the plan of construction recommended by the board of engineers for Buffalo harbor, at their session of March 27, 1868, when convened by order of March 11, 1868, from these headquarters. A copy of their report and recommendations, which are approved, is herewith sent for your guidance.

The work of improvement specified above will be carried on with the utmost diligence, and you will take all the measures necessary thereto.

The south part of Erie basin breakwater will not be removed until authorized from these headquarters.

No contracts or engagements will be entered into beyond the amount of money appropriated.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Brevet Major General T. J. CRAM,
Colonel of Engineers, Detroit, Michigan.

D 14.

UNITED STATES ENGINEER OFFICE,
Detroit, Michigan, April 25, 1868.

SIR: I have taken the liberty of forwarding to you by mail to-day a small package of two simple models, one showing the old method, the other my improvement of framing timber together in cribs.

I also forward my memoir explaining my dissent upon some points from the majority of the board of engineers upon the question of cross-section, &c., of the breakwater for Buffalo harbor. On the point of "combining the timbers" the models will assist better than any drawing could in understanding some of the reasons set forth in the memoir.

After careful reading of the facts it is possible, I may say probable, that some modification of the order of April 3, 1868, to me, in respect to paragraph four, may be thought advisable to be sent to me; especially when a saving of over $150,000 would be the result in the first cost, and a great saving in all subsequent repairs.

The bills of materials are being made out in strict accordance with paragraph 4 of that order, but before putting them into the hands of the contractor there will be time to change them to meet any modification that may be sent to me.

eems to me to be my duty to bring this question of so great a
to your notice before it will be too late for remedy.
have the honor to be, very respectfully, your obedient servant,

T. J. CRAM,
Colonel Engineers, Brevet Major General.

et Major General A. A. HUMPHREYS,
Brigadier General, Chief of Engineers U. S. A.

UNITED STATES ENGINEER OFFICE,
Detroit, April 25, 1868.

In the report of the board of engineers upon the breakwater falo harbor, I, being a member thereof, dissented from the views majority in certain points in respect to the details of the plan of ction of the breakwater, which plans are, as also the estimate, d to the report of the board in answer to the orders reconvening d, from headquarters corps of engineers, March 11, 1868.
oints of my dissent are—
shape of the figure of cross-section of the breakwater.
size of the diameters of some of the timbers.
size of the drift-bolt iron.
the practical method of combining the timbers.
l other respects I agree fully with the majority of the board.
vity, the drawings recommended by the majority of the board lesignated No. 5, and the drawings differing in the points of my and herewith attached, are designated No. 6, this being the n number of all the cross-sections which will have been dis-
No. 5 is that which the majority of the board recommend. No. t which I would recommend.
it may be thought presumptuous or captious in the constructing r to pursue this subject, when the superior authority has d No. 5, and ordered it to be carried into effect. Such motives, , are far from me; I am solely influenced by the desire to do o a subject of such magnitude as the construction of a break- hich must cost more than $500,000; besides, the order of appro- issued before it was possible, owing to other duties, for me to t in intelligible forms the requisite drawings of No. 6.
take occasion here to say that if I fail to convince that No. 6 is l to or better than No. 5, I will just as cheerfully and zealously te in carrying out No. 5 as I would No. 6.
point of dissent: "Shape of the figure of the cross-section," as wn to a scale, [for diagram see original.] Under the diagrams are n juxtaposition the statement of facts in respect to each, from draw comparisons of advantage or disadvantage.

CROSS-SECTIONS IN DEEPEST WATER.

being a "rectangle" with base and variable height, g to depth of water in ie crib stands, the height ean cross-section is 34′, (see lrawn and sent with report .)

,850 running feet of the

No. 6, being a "trapezium" with constant width on top and variable base, according to depth of water, the height of the mean cross-section is (as in 5) 34′, and the base will be 35′, one foot more than its height.

For 1,200 running feet of the

4,000′ breakwater, the base No. 5 will be less than the height; in 350 running feet the base will be just about equal to the height; and in 1,800 running feet the base will be a little greater than the height.

The "prism of thrust" (a, b, c, d,) of the rubble stone filling confined between the walls of the faces of cribs No. 5 is in cross-section 432 square feet.

In No. 5, above low water, there would be in timber and plank 1,777,280 feet, board measure, to rot, and which will require renewing every 10 years to keep it in good repair.

In No. 5 there would be 5,754 cords of stone to handle over at an expense of not less than $1 50 per cord every time of renewing the wood of the parts above water.

In No. 5 a very large portion of the timbers are "long," being 34 feet in length and not affording a sufficient variety of lengths to make it a convenient bill to fill; it will be a "bitter pill" to the contractor.

In No. 5, 37 of the cribs built up as high as represented in the drawing of the board would most probably upset on being floated out to the place where they are to rest, unless buoyed up at much expense.

breakwater the base No. 6 be nearly equal, though very less than the height; for running feet the base wi equal to the height; and fo remaining 2,350 running fe base will be greater than the h

The "prism of thrust" (a, d,) in No. 6 is only 345 squar in cross-section.

In No. 6 the amount of t above low water that will r have to be renewed every 10 is only 1,502,323 feet, board me

In No. 6 the stone to be ha over at every renewal of the above water would be 4,726 at an expense, say $1 50 per

In No. 6 there is a great v of lengths of the timbers, mak a comparatively easy and muc expensive bill for the contrac fill; every stick above 24′ is "long timber" and much mo pensive in proportion to its l above 24′.

In No. 6, all being built t water, (and the superstructure wards put on,) none will up being floated to their final r place.

Several practical conclusions are to be drawn from the above of comparison. In nearly half of the breakwater cribs, No. 5 wo top-heavy, and the general stability of the breakwater would be in of No. 6. The force of thrust of the stones to bulge out the sid bers of the cribs in No. 5 would be greater than No. 6, in the r 1 to $\frac{8}{10}$; all other things being equal, No. 6 would be stronger to the side timbers from being pushed off from the ties in the same

The cost of subsequent repairs of superstructure in No. 5 wo greater than it would be in No. 6, in the ratio of 1 to $\frac{83}{100}$.

There are several places on the lake where the forces of wave a are quite as great as at Buffalo, and where a thickness of pier l considerable than 24 feet has successfully resisted, and where known that the waves when greatest are entirely broken before sh over the pier into the inner harbor to do any harm. Indeed our e ence teaches us that 24 feet for a thickness at top is ample, and th exposed to the heaviest waves being so near a vertical as No. 6, all probability satisfy the fastidiousness of those who think th waves should be met with a vertical wall to be most effectually st broken or resisted.

ıd point of dissent: "Size of some of the timbers." Besides the ·nience already alluded to of not affording a sufficient variety in of the timbers in No. 5, the transverse, also the longitudinal timbers, are unnecessarily large, and the floor timbers of the e not of the most proper thickness and depth. The covering re too thick. Experience shows that on our piers the 2-inch ıger than the 3-inch or 4-inch plank; a result easily accounted for, ich I have seen. It is not to be supposed that the top of this ·ater is to be used for dock purposes.

l point of dissent: "Size of the drift-bolt iron." In No. 5 it ch square; in No. 6, 1 inch square. In No. 5 they are generally es long; in No. 6, 32 inches long. The size of the iron should upon the quality. I apprehend those bolts which have been ıted as having broken were of cold short, not much better than ·n. I know from experiment that our Lake Superior iron, made ·ing with other ore to harden and stiffen it, affords us drift- ·or harbor works of very superior quality, having sufficient s not to bend in driving, and great toughness to prevent break- think 1¼-inch unnecessarily large; it should not be more than d 1 inch square is ample if the bolts are properly distributed and ıere they should be in the structure, and will be less liable to he timbers on being driven; this liability and the increased e are my objections to 1¼-inch iron.

·th point of dissent: "Practical method of combining the tim- This involves not only the manner in which the timbers are ıted and put in the work, but likewise the manner of framing the s to each other; and in order to make these points clear, and to ıem beyond the possibility of doubt or cavil, I accompany the sion with sketches, and introduce for the mathematical deductions sults of actual experiment. The cribs of course should be made enough, by the size and combination of the timbers, to resist moved outwards or inwards; further than this, every additional timber put into the work is objectionable on two accounts: the ·ssary timber excludes so much stone, thereby diminishing the t of the ballast, causing the buoyant effort of the water to have ·ffect to raise the crib; and the cost is enhanced. To illustrate the a cord of stone in the crib costs only $6 85, while a cord of tim- ıamed into the crib costs $46 08.

No. 5 the end pieces of the ıre laid on each other, so as m solid walls, as well as the ieces, and the end pieces are l into the side pieces by a "dovetail tenon" set two feet n the end of the side timbers, ıg what is vulgarly called the ·horned crib," the horns shown

No. 5 the cross-ties are like- aid on each other, forming ıartition cross-walls, and are l into the side timbers with a "dovetail tenon;" at all the gs of the end timbers and

In No. 6 the end timbers of the cribs are laid on each other, so as to make solid walls, as well as the side timbers, but the end and side timbers at the corners of the cribs are framed together by the "double dovetail lap," designed by myself some few years since to obviate the weakness of the single dovetail ten- on. This double dovetail lap does away with the horns.

In No. 6 the cross-ties are *not* laid on each other, each being one stick without splice, and in each tier rise one above another, but separate from each other one foot or by a space equal to the vertical rise of

cross-ties with the side timbers, each side timber is cut half away, leaving cross-section thereof only 72 square inches.

In No. 5 the longitudinal partition timbers are likewise laid on each other, forming a solid wall; and where they cross with the end timbers and cross-ties, each the end timber, the cross-tie, and the longitudinal timber is notched half away, making the cross-section 72 square inches.

In No. 5 the single dovetail tenon has its neck only of 54 square inches in cross-section, and its bevel surface or wedging part only 74.2 square inches, and this, of course, is the holding of the two side timbers when the tenon is inserted between them.

a side timber and joined to the side timbers by the "double dovetail" designed by myself.

In No. 6 the longitudinal partition timbers also rise by the same space between them and pass through the spaces between the cross-ties, and are double dovetailed into the end timbers of the crib where the longitudinal partition timbers and cross-ties cross; every other one only is cut half off and are left with their full strength at the center and bolted there, and thus forming solid piers at the center of the crib.

In No. 6 the double dovetail has 64 square inches in cross-section of its neck and 253 square inches bevel or wedging surface to hold the two side timbers where the double dovetail is framed in.

Notwithstanding the solid transverse and longitudinal partition walls introducing double the number of timbers in No. 5, it is demonstrated (pages 9 to 12 in this memoir) that No. 6 is much stronger at all the joints and in all its parts to resist the thrust of the filling; and besides the saving in timber and allowing more stone ballast, it is very much less expensive in labor of framing than No. 5. Any weakness that might be supposed to arise by halving (as we do in No. 5) two-thirds of the cross-ties into the longitudinal partition timbers where they cross, is more than compensated by the system of truss-bracing I introduce for the longitudinal partition timbers, (sheet D,) or block in, as shown at *a* in that sketch.

A combination of timbers (as in No. 5) necessitates the "horns" of two feet in length at each corner of every crib in the whole line of breakwater. These horns are weak, and do not well resist the thrust of stones put in to fill the four-feet spaces between the crib ends; besides, it is very difficult to adjust one crib with its horns fairly against those of the next crib; the openings which in consequence are left allow ice to get in around the horns, where it clings with great tenacity; whereas making the cribs without horns, as in No. 6, there is much less difficulty in placing them tightly end to end; and if a joint be found open after the setting it can be readily closed by inserting board wedges; and should one end of the crib after setting be found to overhang the fellow end of the next, before being brought to join, can be furnished with two rows of boards placed up and down in shape of an inverted wedge nailed on, with such thickness as will lay tightly against the overhanging crib end. Another advantage of No. 6 is, that one crib can be firmly attached to the other six inches below the surface of the water by strong drift or nut and screw-bolts; to such a connection I attach importance.

None of these advantages obtain for No. 5; and when sunk, cribs No. 5 will present the appearance viewed directly downward, illustrated in

he right-hand sketch seen on sheet A. To have the cribs extend all he way independently from the bed of the lake to the very top of the tructure, as in No. 5, is highly objectionable; from where the wave ction is most effective to the top, there is no bond to keep the cribs in line, or to connect one with the other; all are independent, like a row of bricks, and in stability not unlike a row of fence-panels without the stiffening cap-rail. Whereas, carry the cribs proper up to the surface of the water, as in No. 6, and then put on a running superstructure, covering the whole series, breaking joints in the side timbers as one would do in masonry walls, the whole series of cribs would be vastly stiffened and bonded just where there is the most need, and we should be enabled to present to the eye a uniform, unbroken structure for the upper part of the breakwater.

The cross-ties of the superstructure should be directly over those in the foundation cribs, making the stone pits continuous, like a well, from top of superstructure to the bottom of the crib, a condition that should be insisted on in every pier; in this way the cross-ties of the superstructure, as also those of the cribs, are relieved, in a measure, from the breaking force of the ballast. No. 5, however, enjoys this advantage equally with No. 6.

Comparisons of the holding capacity of my double dovetail and the old single dovetail tenon, also my double dovetail lap.

On commencing to repair the old piers in 1864, wherein the cribs and the superstructure were framed universally with the single dovetail tenon, it was observed that the prism of thrust of the stone filling had in hundreds of places forced the side timbers away from the tenon, and thus made openings under water for the stones to escape and serious breaches to occur.

This great defect in original framing I endeavored to remedy by designing my double dovetail for the ends of the cross-ties, and the double dovetail lap for the corners of the cribs, and thus gaining strength, also doing away with the old-fashioned horned cribs. These improvements have been followed in all my works since 1864, and every experienced mechanic familiar with the old method, and who has framed by the new, is ready to certify to the great superiority of the latter.

Again, another weakness was observed: in a great many cases the neck of the old tenon of the ties was broken off from the want of sufficient cross-section there to resist the breaking force. My double dovetail joint has a bevel or wedging surface to resist any force to push or thrust off the side timber of 259.16 square inches; and the cross-section of the neck is 81 square inches where we bevel one-fourth, as in the cases of No. 5 or No. 6.

The old method (No. 5) allows $74\frac{2}{10}$ square inches only for the bevel or wedging surface to resist the thrust, and the neck of the tenon only 54 square inches to resist being broken.

Now suppose equal care in framing and bolting the side timbers near the joint to hug the tenon, and exactly the same kind of timber for the ties and side timbers, the ratio of the holding forces is theoretically and exactly the same as the ratio of the wedging surfaces. Hence, calling F the force of the double dovetail to prevent the side timbers from being pushed off by the prism of thrust, and f the preventing force of the single dovetail tenon, we shall have f: F:: $74\frac{2}{10}$: 259.16, or as 1 to 3.49; and the resistance to breaking at the necks being represented by B for the double dovetail, and by b for the single dovetail tenon, we shall have b: B:: 54: 81, or as 1 to 1.5.

Again, the labor of framing the double dovetail is just one-third of that of framing the single dovetail tenon.

Again, in the double dovetail one of the embracing side timbers at the joint is cut half away, leaving the cross-section 72 square inches, while the other embracing timber is not cut half way; it has left at the joint 90 square inches in cross-section, and both have left 162 square inches in cross-section there. Now, in the single dovetail tenon both of the embracing side timbers (as in No. 5) are cut half away, leaving the cross-section of both there only 144 square inches; calling S and s the strengths, respectively, of the side timbers at the joints of the double dovetail and the single dovetail tenon, we shall have s: S :: 144 : 162 :: 1 : 1.13. And the labor of framing is in favor of the double dovetail in the same ratio.

We now come to the double dovetail lap at the corners in No. 6 to compare with the single dovetail tenon, as in No. 5; call the holding force of the former C, and that of the latter c, and we shall have c: C :: 74.2 : 153, or as 1 : 207; and the area of the cross-section there is 72 square inches for each, just the same as in the single dovetail tenon, which gives four horns to the crib. But the labor of framing is not even one-fifth as much for the double dovetail lap as for the single dovetail tenon.

I have performed some experiments upon models with a very nice testing machine, kindly furnished me by the Detroit Bridge and Iron Works Company, and find that this testing machine gives f: F :: 675 : 1,875, or as 1 : 2.8.

The difference between this and the theoretical is owing undoubtedly to the difference in the wood of which the two models were made, and other differences in practical framing which it is impossible to avoid. Enough, however, has been proven to show the great superiority of the double dovetail and double dovetail lap over the single dovetail tenon for combining the timbers in cribs to resist the effect of the prism of thrust, as also the breaking force at the neck.

In my calculations f will be taken in the ratio to F as 1 : 2.8, the same as resulted from experiment; and c in the ratio of C as 1 : 2.03, so as to give all possible advantage to the old method, notwithstanding other experiments might give a greater ratio in favor of F.

I now take one side of a crib and superstructure of 50 feet in length from the natural bed to deck. To hold the side timbers from being thrust out, we have in No. 5 64 end timbers and 96 cross-ties, and in No. 6 we have 56 end pieces and 59 cross-ties. In 5 the total resisting force, where all have the "single dovetail tenon," will be expended by $64 \times c + 96 \times f$; and in 6 the resisting force will be expressed by $56 \times C + 59 \times F$.*

Let φ be the total resisting force to the prism of thrust in 5, and φ^1 represents the total resisting force to the prism of thrust in 6, and we shall have $\varphi : \varphi^1 :: 64 \times c + 96 \times f : 56\ C + 59 \times F$.

Let us now take the portions of No. 5 and No. 6 below water, and determine the relative force to prevent the side timbers from being pushed out by the prism of thrust, representing the force in No. 5 by γ, and in No. 6 by γ^1. We shall have $\gamma = 46 \times c + 72 \times f$, $\gamma^1 = 58 \times C + 43 \times F$, from which substituting the ratios we find $\gamma : \gamma^1 :: 118 : 254$, or as 1 : 2.15. From which we see the under-water part of 6 is a little more than twice as strong to resist the prism of thrust. Again, let us leave out the end pieces of the cribs under water, and represent the force to resist the

*From which, by remembering that $c = f$, and the foregoing relation between f F and c, we obtain $\phi : \phi^1 :: 160 : 278\ 88$, or as 1 : 1.743.

t in No. 5 by φ, and in No. 6 by φ^1, and we shall have $\varphi = 72 \times f$, and
$\times$ F; substituting the ratio of f to F we shall find $\varphi : \varphi^1 :: 72 : 120.4$,
1 : 1.67. Hence we perceivet hat in all parts No. 6 has great supe-
r in strength to resist the prism of thrust over No. 5.

ow come to the consideration of the strength of the crib to resist
forced inwards, or broken to pieces by an exterior force acting
st it.

only force known which would be likely to produce this effect
5 or 6, is that of a vessel running into it. No cribs yet constructed
fectually prevent being damaged by this cause.

as far as experience teaches us in the several examples I had to
of this kind, the cribs of solid walls have been the most damaged,
to their rigidity and non-yielding to the shock.

veland pier-heads, the Milwaukee piers, and others I could
ice, built with the solid walls, have been more damaged than
built as No. 6 have been when run into the same way.

greatest span of the cross-ties without support in No. 6 is only
15 feet; and in the longitudinal partition timbers, 11½ feet. To
the partitions I would not resort to the primitive carpentry of
walls, but if necessary would use the modern method, which is
y by trussing from top to bottom with 3×12 stuff firmly spiked to
des of the transverse and longitudinal partition timbers, thus intro-
g the system known by all who understand carpentry under the
nations of "main and counter bracing;" in this way the partitions
. 6 can be made as immense in strength as there is any necessity
is breakwater. The sketch shows the method.

timate of the cost of fifty feet of breakwater, mean depth, No. 6.

MATERIALS.

2 feet, board measure, timberand lumber, at $20 per thousand	$1,983 84
8 pounds 1-inch square drift-bolt iron, at 3⅞ cents	350 61
4 pounds 1-inch round-iron nut and screw bolts, at 4½ cents	8 77
7 pounds spikes, at 5½ cents	19 63

WORK.

9 running feet framing, at 12 cents	964 68
feet, board measure, joists, planks, scantling, and braces, at $7 per thousand	42 83
cords rubble stone, furnishing and putting into the work, at $6 85 per cord	2,255 36
	5,625 72
10 per cent. for contingencies	562 57
	6,188 29

is being the cost of 50 feet at mean depth of water, and there being
feet in the whole breakwater, we multiply this by 80 and we shall
for the total cost of No. 6 ..... $495,063 20
majority of the board estimated No. 5 to cost 657,663 20
rence in favor of No. 6 ..... 162,600 00

Both estimates are upon the same prices as those for which the materials and work are contracted.

It results that in cost, besides the other advantages claimed for No. 6, this is less expensive than No. 5 in the ratio of 1 to 1.33, nearly.

On sheet E are detail drawings of 100 running feet of the breakwater in plan elevation, and sections No. 6, which can be compared with those which I have called No. 5 and sent with the report of the board.

I have the honor to be, very respectfully, your obedient servant,

T. J. CRAM,
Colonel of Engineers, Brevet Major General.

Brevet Major General A. A. HUMPHREYS,
Brigadier General, Chief of Engineers U. S. A.

D 15.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., May 7, 1868.

GENERAL: Your communication of the 25th ultimo, explaining your dissent from the opinion of the board of engineers, of which you were a member, upon the question of cross-section, &c., for the breakwater at the harbor of Buffalo, has been received, as also two models of methods of framing crib-timbers.

The board of engineers constituted by special orders No. 4 was reconvened by special orders No. 31, to take into consideration your letter and memoir of March 5, 1868, in which you suggested a cross-section of a breakwater as a substitute for that unanimously recommended by the board.

At this second session the board maturely reconsidered the whole subject, and submitted certain plans and specifications differing from your own for the breakwater in question. These were approved and you were instructed to conform to them.

Upon due consideration of this second memoir, it is not deemed advisable to make the change you now propose in the plan thus finally adopted. You will, therefore, be governed by the instructions already given.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Brevet Major General T. J. CRAM,
Colonel of Engineers, Detroit, Michigan.

APPENDIX E.

UNITED STATES ENGINEER OFFICE,
Oswego, New York, August 8, 1868.

SIR: I have the honor to transmit herewith my report of progress upon the works of harbor improvement and surveys in my charge, during the year ending June 30, 1868.

As stated in my report of last year, the obstacles placed in the way of constructing officers by the provisions of the acts of June 23, 1866,

Chief of Engineers U. S. A.,
Headquarters Corps of Engineers,
Washington. D. C.

IMPROVEMENT OF BURLINGTON HARBOR, VERMONT.

harge of this work was transferred to Brevet Lieutenant Colonel arlow, captain corps of engineers, in December, 1867. Up to that ntracts had been made by me for the labor and materials, except- the timber, which last was delayed from causes arising entirely aw making the appropriations.

IMPROVING HARBOR OF PLATTSBURG, NEW YORK.

ebuilding of the breakwater, on which was the work contemplated ing the appropriation, being fortunately in the hands of but one tor, (a reliable man,) progressed steadily satisfactorily during the , and it was entirely finished and paid for in January, 1868. ebruary the charge of the harbor was transferred to Brevet Lieu- Colonel J. W. Barlow, captain corps of engineers.

IMPROVING HARBOR OF OGDENSBURG, NEW YORK.

ntract for dredging at this place was made with Mr. A. A. Dodge, on, New York, on the 9th of August, 1867, under which he removed, he 30th of November, about 12,000 cubic yards of material in the y of the custom-house wharf. Instead, however, of resuming work spring of 1868, he abandoned it on the ground that the material ich harder and more difficult to excavate than he had been led to

ther he could have saved himself from loss, with even the softest al, at his extremely low contract price, (17 cents per cubic yard,)

A partial report having been made by this board, orders were issued from headquarters to invite new proposals for dredging in the Oswegatchie river proper, and upon the outer bar north of the light-house.

Contracts have not yet been made under this advertisement.

The plan of permanent improvement suggested by this board contemplated the deepening of the outer bar, and of the Oswegatchie river at its mouth, and the excavation of a channel along the St. Lawrence front of the town; two piers were also proposed to be constructed along the west and southern edges of the great bank or shoal which fronts the town, their object being to prevent the dispersion of the current of the Oswegatchie over this shoal and to confine it to the regular channels.

These piers, however, were not proposed to be constructed until proved necessary by the shoaling of the channels formed by dredging.

The estimated cost of all these improvements is $150,000, deducting from which the $37,000 still unexpended, leaves the sum of $113,000 required for the entire and permanent completion of the work, should this plan be carried out in full, in which case the sum of $50,000 could be profitably expended during the fiscal year ending June 30, 1870.

Ogdensburg is a port of entry with a light-house, half way between Forts Ontario and Montgomery, 120 miles from each. It has not been practicable to procure, in time for this report, the commercial statistics of the place.

Ogdensburg is the terminus of the Great Northern Transportation Line of propellers, starting from the upper lakes, and of two important railroads.

Cash received during the year ending June 30, 1868	$3,500 00
Cash expended during the year ending June 30, 1868.....	2,881 42
Cash on hand during the year ending June 30, 1868.....	618 58
Appropriation available.....	$37,118 58

IMPROVEMENT OF OSWEGO HARBOR, NEW YORK.

The operations for this object have been the repair of the United States pier and dredging.

The pier has been kept in order under contracts reported last year; the repairs required have not been extensive, being confined mainly to replacing the planking of the outer place where it has been injured by ice and gravel.

One crib of the Franklin pier, so called, must be rebuilt this year; this, and other repairs which may be needed from time to time this season, will be done under a contract made in May.

The dredging has been continued and has resulted in a great improvement, especially along the line of the pier, and it is believed that by the close of November, 1868, by far the greater part of the harbor will have a depth of 12 feet.

The construction, by private parties, of certain wharves, not objected to by the United States, will reduce the area requiring dredging. For this reason no further appropriation is asked for next year, except for the new pier extending northward from the light-house into the lake, for which $50,000 is needed, as stated in my last report.

The old west pier, though now requiring small repairs, except the crib above referred to, is, in reality, in a precarious condition, and a severe gale, or the action of ice, may render necessary the expenditure of a large part of the balance now on hand.

As stated in my last report, a new pier exterior to the present may eventually, with the increase of business, become necessary. No estimates and plans have yet been made for such a structure, as they can be deferred until the absolute necessity shall show itself.

The place is the center of a very large and increasing commerce, by lake, railroad, and canal, principally in grain, breadstuffs, and lumber; and if any harbor on Lake Ontario is entitled to be cared for by the United States, it seems to me that Oswego has a greater claim than those where an expenditure is desired merely for the purpose of creating a business not yet in existence, and for the furtherance of strictly local interests.

The value of imports for the year ending June 30, 1868, was:

Coastwise	$17,662,866
Foreign	7,632,596
	25,295,462
Duties	$1,224,088 32
Exports, coastwise	$4,951,310
Exports, foreign	1,080,054
	6,031,364

Arrivals: Number, 4,630; tons, 887,879.

Clearances: Number, 4,587; tons, 864,888.

Oswego is a port of entry, with a stone light-house at the harbor entrance, and a fort (Ontario) within the city limits.

The abstracts of contracts, &c., required by law, accompany this report.

Received during year ending June 30, 1868, $19,500; expended during year ending June 30, 1868, $19,550 48; amount of appropriation available June 30, 1868, $49,823 92; amount required for year ending June 30, 1870, $50,000.

IMPROVEMENT OF LITTLE SODUS HARBOR, NEW YORK.

Since my last report the pier has been extended 800 feet into the lake; of this, 500 feet is entirely completed, and the rest is carried up to the water level and filled with stone. This unfinished portion will, it is hoped, be quite finished by the close of the season.

The opening between the pier and the west side of the harbor has been filled by sinking a cheap crib-work loaded with stone and about 650 feet long along the line of the shoalest water. It is believed that this will cause an accumulation of drift material and the formation of a beach on its north or lake side.

The closing of the opening on the east side, between the proposed short east pier and the shore, which, it is thought, should also be done, will much improve the harbor by reducing its exposure to northerly and easterly winds.

The deepening of the channel by dredging has progressed satisfactorily since my last report. A channel 80 feet wide, with 12 feet of water, is now available next the pier. My experience so far seems to show that this channel will be comparatively permanent, and will not require, when once completed, further dredging for several years.

The harbor is in the collection district of Oswego, which is the nearest

port of entry, (15 miles,) and where the nearest light-house and fort (Ontario) are situated.

Its business and commerce are now quite insignificant, though great results are anticipated by the inhabitants from the opening of the harbor and the construction of a railroad running south and tapping the coal region.

Little Sodus, or more properly Fair Haven, harbor, is an excellent one, of sufficient capacity and depth for vessels of the greatest draught, and there is no better harbor of refuge on Lake Ontario.

The plan of improvement adopted, and which has been partially carried out, is to extend the old (west) pier to 15 feet water, to build a short east pier, dredge the channel to 12 feet water, and to close the openings between the shore and the piers.

To execute all this work will probably require the additional sum of $25,000, which can be profitably expended during the next fiscal year.

The abstracts of proposals and contracts required by law are transmitted herewith.

Cash received during year ending June 30, 1868, $58,000; expended during year ending June 30, 1868, $55,673 37; amount of appropriation available, $27,860 51; required for year ending June 30, 1870, $25,000.

IMPROVEMENT OF BIG SODUS HARBOR, NEW YORK.

The work of rebuilding the west pier and dredging the channel, under contracts made and reported in 1866, and additional subsequent contracts, has progressed upon the whole satisfactorily; 840 feet of this pier have been entirely completed, and 240 feet more have been rebuilt to the water's edge and filled up with stone.

Some delay has been caused by the non-arrival of the pine timber from Canada; but it is hoped that at least the unfinished part of the west pier can be completed this year.

The wreck of a schooner in mid-channel, entirely closing the entrance, has been removed, (by contract, of course.) A great quantity of material has been dredged up from the channel, which has been very much improved thereby. But in order that this improvement should be permanent, it will be necessary to dredge out to the full depth the whole width (470 feet) of the channel between the two piers; otherwise, as shown by the experience of the last two years, the whole will assume one general level, the undredged sand gradually washing into the excavated channel. The channel is now 100 feet wide, and will admit vessel drawing 10 feet.

The funds still available are, it is believed, sufficient to do all the necessary work.

This work is in the same collection district as Oswego, which is the nearest port of entry, 35 miles distant.

Fort Ontario, the nearest fort, is at Oswego.

There is a light-house at Big Sodus. The amount of revenue collected *at Oswego*, during the year ending June 30, 1868, was, $1,224,088 32.

I have not been able to obtain in time for this report any statistics of Big Sodus itself. It is, however, quite insignificant, and is likely to remain so for many years.

As a harbor of refuge, it will be of value.

The amount received during year ending June 30, 1868, was $67,000; the amount paid out during year ending June 30, 1868, was $71,670 41; amount of appropriation available, $58,645 46.

as not been practicable to obtain the statistics of the business of ster during the last year, nor can I say precisely what amount of rce or navigation will be benefited by the completion of this

fact that Charlotte, at the mouth of the Genesee river, is the f the flourishing city of Rochester, indicates the necessity of g the piers in order, independent of the fact that they make, with er, an excellent harbor of refuge.

ı received during the year ending June 30, 1868, $58,500; cash led during the year ending June 30, 1868, $55,611 86; amount of riation available, $9,412 04; amount required for year ending 0, 1868, $10,000.

IMPROVEMENT OF OAK ORCHARD HARBOR, NEW YORK.

o the 30th of June, no work has been done at this point. A por- the timber and all the iron required has been delivered, but the ctor for doing the work has not yet commenced, and it is feared ıe will not. If he abandons the work, or if his contract is ed, the awarding the contract to another will involve a delay in mpletion of the work, which, however, will not be injurious to any ant public interest, for the business and commerce of the harbor ite insignificant, and will probably remain so for a long time. As or of refuge, however, it is of some value.

original estimate and appropriation for completion, $87,000, is d to be sufficient, and nothing more is asked for.

Orchard is a port of entry in the collection district of Genesee, s west of the nearest light-house, (at Charlotte,) and 45 miles east nearest fort, (Niagara.)

amount of revenue collected, and commerce and navigation to efited, could not be ascertained in time for this report.

ı received during year ending June 30, 1868, $25,500; cash ex- during year ending June 30, 1868, $12,206 89; amount of appro-

The contractor is the same as for Oak Orchard and Ogdensburg, at both of which places difficulties have arisen traceable directly to the system of awarding contracts to the "lowest responsible bidders furnishing good securities," without any further qualification.

The original estimate for completion was $118,000. It is believed to be adequate; $60,000 has been appropriated, and an additional grant of $58,000 for the next fiscal year is desired.

Olcott is a port of entry in the collection district of Niagara, 18 miles distant from Niagara fort and light-house.

The business and commerce of the place are at present small, but are expected to increase. Should the proposed Niagara ship canal ever be constructed to enter the lake at this point, Olcott would, of course, become of great importance.

Cash received during the year ending June 30, 1868, $21,000; cash expended during the year ending June 30, 1868, $9,328 33; amount of appropriation available, $50,667 77; required for year ending June 30, 1870, $58,000.

C. E. BLUNT,
Lieutenant Colonel Engineers, Brevet Colonel.

U. S. ENGINEER OFFICE,
Oswego, New York, August 8, 1868.

Abstract of proposals and contracts for the labor required for the repair of the United States pier at Oswego, New York, for 1868.

Bidder.	Price of labor.			Contracts.
	Per M feet, board measure, of lumber used.	Per pound of iron.	Per cubic yard of stone.	
Hart & Jennings	$20 00	$0 05	$2 00	
James Caldwell	9 00	02	75	
A. P. Grant, outside work	25 00	02	1 00	
A. P. Grant, main work	12 00	.....	.....	
Daniel C. Gunn	8 00	02	75	Contractor.
George M. Case	11 00	04	1 10	

Abstract of proposals and contract for removing wreck from channel of Big Sodus harbor, New York, 1867.

Bidders.	Price.	Contract.
Zebulon Moore	$1,400 00	Contractor.
William Rankin	2,225 00	
R. R. Dodge	2,929 00	
S. B. Robinson	1,874 50	
A. P. Grant	3,000 00	
Charles E. Hubbell	1,800 00	
Darius Davis	1,650 00	
John Stevenson	1,425 00	
John Farnan	1,850 00	

tract of proposals and contracts for improving harbor of Little Sodus, New York—closing opening west side.

Bidders.	Hemlock lumber, per M feet, b. m.	Iron.		Stone, per cubic yard.	Labor.		Contracts.
		Screw bolts, per lb.	Wrought spikes, per lb.		Per M. feet, b. m., lumber.	Per lb., iron and spikes.	
		Cents.	*Cents.*			*Cents.*	
ulon Moore	$16 00	11	9	$2 75	$15 00	5	
rid Thomas	.....	9	7¼	.....	.....	.....	
nner & Arnold	.....	8	7½	.....	.....	.....	
rid Finley	.....	10	8	.....	.....	.....	
3. Place	.....	7½	7	.....	.....	.....	
i. Gere	15 00	6½	6½	2 00	5 00	2	Contractor for bolts and spikes.
R. Dodge	13 90	7½	7	0 94	4 73	.....	Contractor for stone and labor.
dwell & French	17 50	8	8	.....	7 50	.....	
t & Jennings	12 90	.....	.....	1 35	4 45	2	Contractors for lumber.
tt & Co	.....	8½	6½	.....	.....	.....	
tell & McNett	.....	.....	.....	.....	10 00	1½	

Abstract of proposals for improving harbor of Little Sodus, New York, 1867.

Bidders.	Class 1, timber.			Class 2, iron.			Class 3.	Class 4, labor.			Contractor.
	Hemlock, per M feet, b. m.	Pine, per M feet, b. m.	Snubbing posts.	Screw-bolts, per pound.	Drift-bolts per pound.	Wrought spikes, per pound.	Stone, per cubic yard.	Per M feet, b. m., of timber.	Per pound of iron.	Per lineal foot snubbing posts.	
				Cents.	*Cents.*	*Cents.*			*Cents.*	*Cents.*	
David Thomas				8	7	7½					
Skinner & Arnold				7½	6½	7½					
Zebulon Moore	Hewed $18 00 Sawed 20 00	$37 00 40 00	Per lin. foot 75c	10	9	8½	$3 00	$14 00	4	30	
David Finley				8½	8½	8½					
Pratt & Co				6	6	6					
J. Fredrick Behn	18 00	24 00	Per lin. foot 25c	7½	6½	8½					
William Burke				6.2	5.4	6½					
T. W. Parmenter, agent				7½	5½	7					
Thomas Parsons	15 00	18 00									
C. R. Parsons	14 25	17 00									Contractor for lumber.
R. R. Dodge							1 00				Contractor for stone.
R. S. Place				6½	5½	7					
McDowell & McDonald	21 00	32 00	Each $3 00	8	8	9	2 75	13 00	3		
C. J. De Graw							1 61	8 84	2		
S. B. Robinson				6½	5	7		5 90	0		Contractor for labor.
Asahel Clark	20 ft. long 28 00 30 ft. long 30 00 40 ft. long 35 00 Plank 22 00	30 00 32 00 35 00 28 00	Each 6 00	8½	7½	7	1 86	8 00	1½		
Hart & Jennings								7 24	2		
Caldwell & French	18 00	20 00 Plank 28 00	Per M b.m. 30 00	7	7	7	1 12	5 50	2		
R. N. Gere	Under 20 ft. long 15 50 All others 19 00	28 00 32 00		6½	5½	6½	1 78	8 50	2		Contractor for iron.
David King	9 50							7 50	2½	Ea. 20	
Scutell & McNett							1 90	9 00	1½		

Proposals and contracts for improving harbor of Erie Basin, New York, 1867.

Bidders.	Class 1, timber.			Class 2, iron.			Class 3,	Class 4, labor.				Contracts.
	Hemlock, per M feet, b. m.	Pine, per M feet, b. m.	Snubbing posts.	Screw bolts, per pound.	Drift bolts, per pound.	Spikes, per pound.	Stone, per cubic yard.	Per M feet, b. m., of lumber used.	Per pound of iron used.	Per lineal foot of snubbing posts.	Repairing old pier, per lineal foot.	
				Cents.	*Cents.*	*Cents.*			*Cents.*	*Cents.*		
David Thomas				8	7							
Skinner & Arnold				7½	6½	7½						
Zebulon Moore	Sawed $18 00	$40 00	per lin. ft. 75c	10	9	8½	$2 50	$14 00	4	30		
	Hewed	37 00										
David Finley				8½	8½	8						
Pratt & Co				6	6	6½						
C. R. Parsons	Hewed 14 25	17 00	Each $6 00									
Thomas Parsons	Sawed 15 00	18 00	Each 6 00									Contractor for lumber.
R. N. Gere	Under 20 ft long 15 00	28 00		6¼	6¼	6¾	2 32	8 50				
	Over 20 ft. long 17 50	32 00										
T. W. Parmenter, agent				7¾	5¾	7½						
William Burke				6.2	5.4	6¾						Contractor for iron.
Asahel Clark	40 ft. long 30 00	40 00	per M b. m. 40 00	9	7¾	7	2	15 00	1			
	Under 40 ft. long 25 00	35 00						10 00				
Scutell & McNett							1 90		1½		20c	
R. R. Dodge				6½	2 ft. 5¼	7½	1 55					Contractor for stone.
McDowell & McDonald	20 00	32 00	Each 3 00	8	8	9	2 50	13 00	3		$3 00	
C. J. DeGraw	Hewed 14 00	28 00	Each 15 00				1 80					
	Sawed 16 00	30 00										
Hart & Jennings	Hewed 15 25	21 75	per M b. m. 29 00	8	7½	8	1 65	7 75	2		1 50	
	Sawed 17 00	24 00										
Caldwell & French	18 00	Timber 19 50	per M b. m. 30 00	7	7	7	1 25	6 00	2		1 00	Contractor for labor.
		Scantling 12 00										
		Plank 27 00										
William Rankin	30 ft. long 18 00	18 25										
	18 and 20 ft. long 13 00	17 00										
	Plank 12 50	24 00	Each 5 00					8 50	5			
J. Fredrick Behn	18 00	24 00										

E 1.

OSWEGO, *January* 6, 1868.

SIR: I have been called upon within a few days, by Judge Churchill, member of Congress for this district, and Mr. Carrington, president of the Board of Trade of this city, in relation to the extension northwardly into the lake of the United States pier at this place. Mr. Carrington represents the commercial interests of Oswego, which is very anxious that this extension should be commenced as soon as possible.

In my last annual report, and in my letter of April 27, 1867, I have referred to this subject and expressed an opinion favorable to the proposed structure. Since then, with additional experience here, I have become still more convinced of the necessity of the desired extension, not only for the reasons assigned in my communications above referred to, but for two additional ones. First, the proposed pier will serve to arrest the eastward progress of the gravel drift, which now, in crossing the entrance, has a tendency to form a bar there; and second, it will decidedly lessen the risk now run by vessels entering the harbor during a gale of being driven against the *east* pier, inasmuch as it will, by making a lea, cause smooth water between the two piers. Two vessels with valuable cargoes have been sunk this fall at the very entrance, which, it is most probable, would have got in safely had this proposed pier been built.

In my last annual report I suggested as a reason for deferring this construction its possible interference with any new *permanent* outer pier, should such be built; but independent of the very great uncertainty of the building of such a permanent outer pier, which would involve a *very large* expenditure. I am now of opinion that, if built, it would be so placed that the one now discussed would in no way injure the new harbor.

I therefore, at the suggestion and request of the gentlemen I have mentioned, respectfully suggest the advisability of calling for an *additional* appropriation of $50,000 for the improvement of Oswego harbor, to be applied in the construction of this pier. A length not under 400 feet will be required, which, supposing it to be in 20 feet average depth of water, will cost that amount. I do not consider it quite safe (supposing such a use admissible) to use the appropriation now available, or the $25,000 I asked for in my annual report for this particular purpose, for the present pier is in such a condition, notwithstanding constant patching, that there is no knowing what serious damage may be caused by the winter and spring gales, occasioning large expenditures for its repair.

Very respectfully, sir, your obedient servant,

C. E. BLUNT,
Lieut. Colonel of Engineers, Brevet Colonel U. S. A.

General A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

E 2.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., May 11, 1868.

COLONEL: Your letter of the 8th inst., respecting improvement of harbor of Ogdensburg, is received.

The letter to you from this office of the 20th April directed the dredging to be done in the two channels proposed by General Reese and recom-

ded by the board of engineers of which you were a member, which
nmendation was approved by me, and you were directed at the
to carry out the plan. The recommendations of your letter of the
nst. are chiefly for work at other localities. With the statements of
letter before me, I cannot authorize any project to be carried out
the subject has been more thoroughly investigated.
u will at once make a survey comprehending the whole of the
400 yards north of the light-house, and the channels adjacent to
st and west, north and south. The survey of General Reese con-
cts the existence of such a shoal completely barring the entrance
e Oswegatchie.
board will be ordered to convene at Ogdensburg on the 15th inst.
vise a plan for the improvement of the harbor.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

evet Colonel C. E. BLUNT,
Lieutenant Colonel of Engineers, Oswego, N. Y.

E 3.

edings of a board of engineers convened at Ogdensburg, New York, by virtue of the following special order:

[Special Order No. 56.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., May 11, 1868.

board of engineers, to consist of Brevet Major General John New-
lieutenant colonel corps of engineers, Brevet Colonel C. E. Blunt,
enant colonel corps of engineers, Brevet Colonel D. C. Houston,
r corps of engineers, with Captain Asa H. Holgate, corps of engin-
as recorder, will meet at Ogdensburg, New York, on the 15th inst.,
soon thereafter as practicable, to devise a plan for the improve-
t of that place.
e board will be furnished by Colonel Blunt with all the reports,
, correspondence and information relating to the harbor, in his
ession, and it will make such surveys and examinations as may be
sary to a complete investigation of the subject, and will report in
l upon the improvement of the harbor.
command of Brigadier General Humphreys:

THOMAS LINCOLN CASEY,
Major Engineers, Brevet Colonel U. S. A.

OGDENSBURG, N. Y., *May* 15, 1868.

e board met at 2 p. m., pursuant to the foregoing order. All the
bers present; Captain A. H. Holgate, the recorder, absent.
e board examined the maps of the harbor of Ogdensburg, and
ssed the general question of the improvement of the harbor. The
l then visited the different points on the shore commanding a view
e harbor and examined the line of wharves.
e board adjourned at 8 p. m. to meet at 9.30 a. m. on the 16th.

MAY 16, 1868—9.30 a. m.

The board met pursuant to adjournment, all the members being present.

The board was called to order by the president. Captain Holgate stated as a reason for his non-appearance at the preceding meeting, that he was detailed as officer of the day before receiving the above order, and was only relieved on the morning of the 14th inst.; that he started on the same day, and reached Ogdensburg without delay.

The recorder read a series of papers which were presented by Colonel Blunt, as relating to the matter under consideration, dated and signed as follows:

1. Dated Fort Montgomery, Rouse's Point, N. Y., November 7, 1866; signed by Brevet Brigadier General C. B. Reese, corps engineers.

2. Dated Ogdensburg, N. Y., April 15, 1867; signed by Brevet Colonel C. E. Blunt, corps engineers U. S. A.

3. Report of board of engineers, of which Brevet Brigadier General Hartman Bache was president, June 18, 1867.

4. United States engineer office, Oswego, N. Y., April 15, 1868; signed by C. E. Blunt, lieutenant colonel engineers, brevet colonel.

5. United States engineer office, Oswego, N. Y., April 15, 1868; signed signed by C. E. Blunt, lieutenant colonel engineers, brevet colonel.

6. Headquarters corps of engineers, Washington, April 20, 1868; signed by A. A. Humphreys, brigadier general commanding.

7. United States engineer office, Oswego, N. Y., May 8, 1868; signed by C. E. Blunt, lieutenant colonel engineers, brevet colonel.

8. Northern Transportation Company, Ogdensburg, N. Y., March 28, 1868; signed George A. Eddy, agent.

9. Dated Ogdensburg, March 31, 1868; signed A. B. James.

10. Ogdensburg and Lake Champlain railroad, superintendent's office, Ogdensburg, N. Y., March 31, 1868; signed W. C. Brown, general superintendent.

11. Ogdensburg, N. Y., April 3, 1868; signed George Parker.

12. Ogdensburg, N. Y., April 10, 1868; signed C. & D. Whitney, jr., & Co.

13. Dated land office of George Parrish, Ogdensburg, N. Y., April 11, 1868; signed John F. Rosseel.

14. Headquarters corps engineers, Washington, D. C., May 11, 1868; signed A. A. Humphreys, brigadier general of engineers, commanding.

The following resolution was unanimously adopted:

Resolved, That Colonel Blunt be requested to make a new survey of the in-shore channel leading from the old harbor towards the depot of the Lake Champlain and Ogdensburg railroad, and to determine the force and directions of the currents in the Oswegatchie channel from the outlet of the old harbor to a point outside the bar; the same in the channel leading along shore from the old harbor towards the depot of the Lake Champlain and Ogdensburg railroad. The same at various points on the large shoal from the bar to the depot of the Lake Champlain and Ogdensburg railroad; the same of the St. Lawrence river in the immediate neighborhood of the bar, and of the main current of the river; the low water as nearly as possible, and the range of high water; the character of the bottom bearing upon the question of the deposit of silt.

The board adjourned at 5 p. m. to meet on Monday, the 18th, at 9 a. m

OGDENSBURG, N. Y., *Monday, May* 18, 1868.

ıe board met pursuant to adjournment, all the members being pres-
and the following was unanimously adopted:

e board of engineers convened by Special Order No. 56, headquar-
orps of engineers, dated May 11, 1868, have the honor to submit
llowing preliminary report:

board, after an examination of the harbor and maps, and after
nsideration of all the correspondence relating to the improve-
f the harbor of Ogdensburg as submitted by Colonel Blunt, the
ngineer, are of the opinion that the operations immediately neces-
r the improvement of this harbor, and which should be com-
l at the earliest practicable moment, are as follows, and that
ould be executed in the order stated:

epening the water by dredging at the wharves of the Northern
d, and Northern Transportation Company, so as to allow vessels
h the wharves in 12 feet at the lowest stage of water. This
is designated as section C on the sketch sent to the engineer
nent with Colonel Blunt's letter dated May 8, 1868. Also
ıg the bar about 400 yards north of the light-house, so as to
a channel 300 feet in width and 12 feet deep at the lowest stage
er.

redging the channel of the Oswegatchie river below the bridge,
n the wharf lines, to a depth of 12 feet at the lowest stage of
This locality is designated as section A on the sketch sent to
gineer department with the letter of Colonel C. E. Blunt, dated
1868. This improvement, with that of the bar above mentioned,
ıes all the facilities desired at the old harbor.

elation to the dredging at the wharves of the Northern railroad,
ıe Northern Transportation Company, the board, while it admits
olute necessity to the large numbers of vessels receiving and dis-
ng cargoes at these wharves, yet in view of the fact that there is
nt water in the approaches to these wharves, the obstructions
at or close to them, are of the opinion that it belongs of right to
oprietors of the wharves, and not to the general government.
nount estimated for this part of the work is not over four thou-
ollars, ($4,000,) and the dredging is easy of execution.

ddition to the work already recommended there is required,
for the future development of harbor facilities at this place, a
ıous in-shore channel along the bank of the St. Lawrence, 12 feet
t the lowest stage of water.

water fronts of property fronting on this channel are now unim-
l, and the immediate requirements of the present business of the
ıre provided for by the works above recommended, which it is
d will consume nearly if not all of the funds available for this
r.

rder to locate the position and extent of this channel, and to
complete investigation and report upon the improvements of
rbor as called for by the order convening the board, it is now
ıry to await the result of the additional examinations which the
as directed, by its resolutions, to be made, but these examinations
ot affect the necessity already expressed of dredging the bar and
harbor.

ved, First. That in the opinion of the board, so soon as the sur-
the bar ordered by the Chief of Engineers has sufficiently pro-
, the engineer in charge be authorized to advertise for proposals
ge there in order to secure a channel of the width and depth
d in this preliminary report.

Second. That the engineer in charge be authorized to include with the above proposal the dredging of the channel of the Oswegatchie below the bridge, designated as section "A" in a sketch sent to headquarters corps of engineers with the communication of Colonel C. E. Blunt, dated May 8, 1868.

Third. That Colonel Blunt be instructed as soon as he has completed the observations and surveys as directed, to report the result to the president of the board.

The board, having no further business before it, adjourned at 10.30 a. m. to await the call of the president.

JOHN NEWTON, *Lieut. Col. Engineers, Bvt. M. G.*
C. E. BLUNT, *Lieut. Col. Engineers, Bvt. Col.*
D. C. HOUSTON, *Major Engineers, Bvt. Col.*
A. H. HOLGATE, *Captain Engineers, Recorder.*

OGDENSBURG, N. Y. *May* 18, 1868.

Received at Ogdensburg, May 18, 1868.

C. E. BLUNT,
Lieut. Colonel Engineers, Bvt. Col.

Statement of certain residents of Ogdensburg as to the importance of the in-shore channel.

Respectfully forwarded to headquarters corps of engineers, with the preliminary report of board of engineers, convened by Special Orders No. 56, dated May 11, 1868.

It appears from this petition that, as stated in the report of the board, the improvement asked for relates to the prospective business of the place, and so far this agrees likewise with the views expressed to the board by those concerned in the existing centers of business.

By order of the board.

A. H. HOLGATE,
Captain Engineers, Recorder.

OGDENSBURG, N. Y., *May* 15, 1868.

DEAR SIR: Learning that you "wish to ascertain the general opinion here as to the propriety or necessity of cutting a channel 100 feet wide along the St. Lawrence toward the Ogdensburg and Lake Champlain railroad depot, as recommended by General Reese, in his report of 1866," we beg respectfully to represent, that while individual interests demand and should have attention, as far as general or public interest is concerned, the work referred to is of the first general importance, and for these reasons: More wharves are needed; parties engaged in the lumber, coal, and stave business are prevented from establishing themselves here for the want of wharf room connected with the Ogdensburg and Lake Champlain railroad. The Clifton Iron Company contemplate the shipment of great quantities of iron ore to the west from this point after the present season. The Northern Transportation Company is adding largely to its line of steamers, and it is desirable that facilities for this increase of commerce should be found near our centers of business, rather than at points remote.

We are informed that the property owners along the line of the proposed channel, if made, will wharf out to it at once, thus showing their

ıce that the wharves will be in demand, and thereby add a large to the taxable property of our city.

onstruction of this channel would insure the extension of the ›urg and Lake Champlain railroad to the upper harbor, giving ;able water and wharves with railroad connection along the ;er front of our city.

', in the opinion of citizens who are best acquainted with the ence river, the winter steam ferry which is now maintained only ;densburg and Lake Champlain railroad station, might be kept ıear the summer landing.

Very respectfully,

›uck.	John Barber.
lwell.	C. P. Clark.
ris.	Adm. Vilas.
›.	R. H. Houston.
b.	H. T. Bacon.
by.	J. S. Johnson.
rtrand.	J. L. Ives & Son.
›tt Smith.	Edwin Clark.
strong.	P. Hackett.
ls.	Chas. Wells.
& Gilbert.	H. G. Goodno.
.	H. Chatterton.
nedict.	I. B. Armstrong.
›uck, jr.	Messrs. Jam. Hasbrouck, by S. H.
. Gibbs.	

E. BLUNT, *United States Army.*

E 4.

NEW YORK, *May* 19, 1868.

AL: In forwarding the report (preliminary and partial) of the ard convened to devise a complete and detailed plan for the ent of the harbor of Ogdensburg, the members have desired d therewith an accompanying letter in explanation.

ırd in recommending immediate action for the improvement of ıg centers of business, which is not only necessary in itself rmable to reason and usage, in utilizing existing facilities have led to depreciate the importance of the deepening of the in-shore ading from the old harbor to the depot of the Lake Champlain nsburg railroad.

ish to acknowledge the great benefit and convenience which ınel would prove to the development of trade, but it was like- ssary to ascertain in the first place the prospect of rendering ınel secure against filling up after being dredged, and the expense of keeping it open. Other points also engaged their viz: the probable necessity of work of construction for the on of the required depth over the bar, and of the in-shore ›ove described. Examinations, which at the lowest calculation sume several weeks, were necessary in order to satisfy the oming to a just conclusion upon the points in question, and ›ers of the board feel compelled to render a partial report

and await the information expected from these examinations in order to complete their investigations and report.

It is proper to remark that some doubt existed in the mind of the board as to the accuracy of the hydrography of the map made by Mr. Judson, and sent with General Reese's report, and that the members of the board are altogether uncertain concerning the reference of the bench mark used for reducing soundings of that survey. With regard to the dredging at the docks of the depot of the Lake Champlain and Ogdensburg Railroad Company, and by the Northern Transportation Company, the members of the board were strongly impressed with the necessity of this being effected perhaps the very first in order, for the purpose of accommodating this important and growing commerce; but they could not affirm a precedent for performing such work out of the funds of the government at the wharves of a private corporation, when the channel approaches to such wharves were unobstructed. It is proper to remark that the president of the railroad company assured the board that such work would have been done at the expense of the company had it been possible to obtain the services of a dredge from the neighborhood, but he stated that all the dredges in Lake Ontario were working under existing contracts with the government.

Very respectfully, your obedient servant,

JOHN NEWTON,
Lieutenant Colonel of Engineers, Brevet Major General U. S. A.

Brevet Major General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

E 5.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., May 26, 1868.

COLONEL: The preliminary report of the board of engineers convened at Ogdensburg, New York, on the 15th May, 1868, in obedience to Special Order No. 56, to devise a plan for the improvement of the harbor at that place, having been approved at these headquarters, you will proceed to carry out the views of the board; and as already instructed, you will advertise anew for proposals for the necessary dredging in the localities and in the order recommended.

A copy of the preliminary report of the board, being an extract from their proceedings, is herewith transmitted for your information.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Lieut. Col. and Brevet Col. C. E. BLUNT,
Corps of Engineers, Oswego, New York.

E 6.

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., May 8, 1868.

SIR: Shortly after receiving headquarters letter of the 20th ultimo, relating to the subject of dredging at Ogdensburg, New York, I visited that place for the purpose of making myself as fully acquainted as possible with the requirements of commerce and business at that port, by

erence with the prominent representatives of the various interests
h I have found there, and also by personal examination of the
or. I have already informed headquarters that these various inter-
differed in their views as to the locality in which the appropriation
d be expended, and that it would be difficult to please all. I still
e to this view of the matter, though I have been able to bring about
ain amount of unity; and I propose now to submit a plan of opera-
which, it would seem, will give a reasonable amount of satisfaction.
ore doing this, however, I beg to report the result of the personal
nation made by me, so far as I could arrive at one, leaving some
, however, unsettled until I receive a report of the borings which I
found it necessary to have made.
eral Reese, in his report of November 7, 1866, speaks of "two
ss centers" at Ogdensburg. In this he is entirely accurate. The
r, or the space between the bridge across the Oswegatchie river
s mouth, that is, as far as the line where the river originally en-
the St. Lawrence, with a few adjoining wharves partly on the St.
nce front and some at the Rome and Watertown railroad depot, is
o a great extent for milling and manufacturing purposes.
other business of the place is transacted at the depot of the Og-
rg and Lake Champlain railroad, and on their wharves by that
d and by the Northern Transportation Company. Immense quan-
f all sorts of property, including grain and lumber, are here trans-
d, and here nine-tenths of the vessels arrive and depart.
business is located on the St. Lawrence, full one mile from the
atchie river. Between the two is a town front only partly im-
l and built upon, and with no wharfage, (with one exception.) The
nication by vessel between these two centers of business is not
equent.
he old harbor—that is within the space first described, and limited
accompanying sketch by the line A B—there is from 9½ to 10 feet of
the river being now very low. The bottom of the greater part, or
river proper, appears to be *very hard*, covered with pebbles and
rs of various sizes, one at least of which is too large to be raised by
ge. I found that this bottom could not be penetrated without bor-
hich I have ordered to be made. So far as the best information
t is a hard pan, underlaid by rock in place, at a depth yet to be
ined, but over four feet. I do not think it is derived from the
in the dam above, except possibly a thin surface layer.
btain 12 feet of water in this section will require the removal
nt 25,000 cubic yards of material, and it is possible that blasting
ve to be resorted to for the large boulders, of which, however,
eems to be only one or two.
g the front of the Ogdensburgh railroad and the Northern Trans-
on Company's premises there is now close to the wharves a depth
from 8½ to 12 feet, there being only about the former depth
the Northern Transportation steamers lie. The bottom in this
appears to be soft, and about 15,000 cubic yards of material should
oved to give 12 feet depth.
een these two points and along the St. Lawrence front there is a
l with six feet of water, the bottom penetrable for a foot or so by
rough the greater portion, but in some parts appearing hard with
. This bottom is to be further examined. To deepen this chan-
2 feet at low water will require about 60,000 cubic yards of dredg-
hese three sections are stated by General Reese to require dredg-
t there is another point which he does not allude to, and which is
inctly shown on the map *of his survey, viz: the outer bar*, directly

north of and about 400 yards from the light-house, where, for a distance north and south of about 400 feet, there is only nine feet of water, and vessels are daily touching. A channel of not less than 300 feet in width should be dredged across this bar, requiring the removal of about 13,000 cubic yards of material, believed to be mainly sand and mud. The prevailing wish at Ogdensburg seems to be to have the first dredging done at the lower harbor, viz: to enable the Northern Transportation Company's steamers to approach and lie alongside the wharves. I send herewith copies of letters received by me on this subject. There is no doubt that dredging is required here, but I observe that no allusion to it is made in headquarters letter of the 20th April. The question as to the limits defining what work should be done at the expense of the United States, and what at the expense of the local business immediately interested, is not one for me to decide or to give any opinion upon.

The upper harbor, or the section below the Oswegatchie bridge, is situated very much like Oswego bridge, viz: a narrow, rapid river, lined on both sides by business establishments. At Oswego the depth in the corresponding part is now, in many places, considerably less than at Ogdensburg, but no one has asked or expects to have the United States expend any money in deepening it. On the contrary, a long strip has been coffer-dammed and deepened by blasting, at the expense of the owners fronting upon it. If the appropriation was obtained by the promoters thereof with any special object, it probably was with a view to deepening this upper and old harbor with the bar before mentioned.

There can be no doubt, for it is openly admitted, that the object designed to be attained by cutting the 100-feet channel along the St. Lawrence front (which is specified in headquarters letter of 20th April) is to bring the adjoining property into market, promote the building of wharves, giving additional business facilities and developing new business.

The actual business does not require this channel; even its advocates admit that it is secondary to the other three points. I cannot recommend its construction at present.

If it is decided that the work near the lower railroad depot and transportation company is not to be done at the expense of the United States, then it is my opinion that the deepening of the bar should be first taken in hand. This may, by a fair construction, be considered as in the "natural channel" of the Oswegatchie, as the greater part of the water passes over it. To make a channel only 100 feet wide over this bar would give little relief, as vessels, entering the channel mostly from the westward, require considerable room in changing their course. A channel also in the section just below the bridge, of only 100 feet, would not be of much use. The lines limiting the dredging in this portion should be, in my opinion, as shown upon the sketch. Between the northern limits of this section, northerly to the bar, there is plenty of water, and little if any dredging is required.

As soon as I receive a report of the result of the borings ordered by me, and have the final decision of headquarters as to the points or sections at which dredging shall be done, I will re-advertise for proposals.

There should properly be three rates of prices, as there are at least that number of kinds of work to be done; but it would be highly unadvisable if not impracticable to make three separate contracts, and have three or four dredges at work with their scows and tug-boats at once, supposing the work to be going on at all the points named simultaneously, as it should, in the opinion of some who think I cannot satisfy everybody otherwise.

My plan would be, therefore, supposing that all the portions of the

are to be dredged by the United States, to commence at the
arbor, or Ogdensburg railroad front; then dredging the outer
xt, the river below the bridge; and lastly, the 100-feet channel
ie St. Lawrence.
ll be observed that I assume 12 feet at low water as sufficient.
rested are agreed as to this. The Welland canal passes only ten
inches, and no greater draught is at all likely to be in use for

d contractor, Mr. A. A. Dodge, has, both verbally and by letter,
ed the contract and removed his dredge. I have accordingly
correspondence with the district attorney at Buffalo, and will
cate his reply to headquarters.
derstood, I believe, at headquarters, that Mr. Dodge's pretext
ie was deceived as to the material, which he has found and
to find much harder than he anticipated. The information
ny office to him and others was based partly on General Reese's
hich was made and furnished me, I suppose, as a basis of expen-
d partly upon such information as was obtained in June, 1867,
ard of which I was a member. Further surveys and detailed
ions were not then supposed necessary by me, and, as directed
arters, I advertised for proposals immediately after the adjourn-
hat board.
se, in my next advertisement, to request bidders to make per-
ts to Ogdensburg. No bid can be understandingly made with-
visit. The great distance which the dredged material must be
an important element in the price.
to keep out bogus and speculative bids, and all bids made by
ontractor, or in which I may know him to be interested. There
be propriety and common sense in this course, if the law will

herewith copies of sundry letters, and extracts from letters
by me from Ogdensburg, as follows: From George Parker,
e April 3, 1868; from A. B. James, under date March 31, 1868;
& D. Whitney, jr., & Co., under date April 10, 1868; from
. Eddy, agent, under date March 28, 1868; from D. W. C. Brown,
perintendent, under date March 31, 1868; from John Rosseel,
e April 11, 1868.
ry respectfully, your obedient servant,

C. E. BLUNT,
Lieut. Colonel of Engineers, Brevet Colonel U. S. A.

l A. A. HUMPHREYS,
Chief of Engineers,
quarters Corps of Engineers, Washington, D. C.

OGDENSBURG, *March* 31, 1868.

SIR: I am just informed that the water in the lower harbor is
it propellers loaded cannot make the wharves.
seel, who takes this note, will more fully explain to you the
of things.
advise that work be commenced at that locality as soon as
o meet the necessities of commerce.
no citizen would complain of so doing.
spectfully yours,

A. B. JAMES.

C. E. BLUNT.

OFFICE OF THE NORTHERN TRANSPORTATION CO.,
Ogdensburg, N. Y., March 28, 1868.

DEAR SIR: In consequence of the low stage of water in the St. Lawrence river this spring, it will be impossible for our steamers to get alongside of the docks formerly used by us at this port, when loaded; and unless you can assign us some other docks and freight houses, where there is a greater depth of water, we cannot bring full cargoes of freight to you this season, unless the water raises or your harbor is dredged out. Trusting you will give this matter your early attention,

I am, very truly yours,

GEO. A. EDDY, *Agent.*

D. W. C. BROWN, Esq.,
O. & L. C. Railroad, Ogdensburg, N. Y.

OGDENSBURG AND LAKE CHAMPLAIN RAILROAD,
SUPERINTENDENT'S OFFICE,
Ogdensburg, N. Y., March 31, 1868.

DEAR SIR: The unusually low stage of water in the St. Lawrence this spring has temporarily almost destroyed our harbor, and by the inclosed letter from the agent of the Northern Transportation Company you will see that we are in pressing need of some relief, or we shall be obliged to stop vessels in the stream, and lighter the freight to and from thence. This would almost destroy our business for the season, and of course damage us very seriously.

I understand that your contractor says his dredges are entirely unsuited to the work of the upper harbor, but that they are just right for the work in the vicinity of our docks. Cannot you direct that he should commence at the lower end this spring, and do enough dredging so that at least vessels can have a channel to get into the docks of this company, and those adjoining, belonging to Mr. Parish?

At least nine-tenths of all the vessels arriving here want to come to these docks. Judge James has promised to write to you, urging this course for the interest of our city, and Mr. John F. Rosseel (the agent of Mr. Parish) has kindly offered to be the bearer of the letters, and to more fully explain to you our pressing need. If you can aid us in the extremity, we shall always be duly grateful.

Yours, very truly,

D. W. C. BROWN,
General Superintendent.

Colonel C. E. BLUNT,
Oswego, N. Y.

LAND OFFICE OF GEORGE PARISH,
Ogdensburg, N. Y., April 11, 1868.

DEAR SIR: * * * * * *
I will only add that should you see fit to refer Mr. Dodge to me for instructions as to *where* the work of dredging shall be done here, I will cheerfully direct him, *without charge*, and, in the language of Judge James, "I think no citizen (or any other man) would complain of so doing."

I am, dear sir, very respectfully,

JOHN F. ROSSEEL.

Col. C. E. BLUNT, U. S. A., *Oswego, N. Y.*

NOTE BY COLONEL BLUNT.—Mr. Rosseel particularly desires dredging ng the Parish wharf and in the so-called "channel" between the two bors. He is Mr. Parish's agent.

C. E. BLUNT,
Lieutenant Colonel Engineers, Brevet Colonel.

OGDENSBURG, N. Y., *April* 3, 1868.

Y DEAR SIR: I hope it will be convenient for you to make a visit to place before the dredging begins this spring, and note for yourself circumstances. At present it would be impossible for a laden vessel he usual Welland canal dimensions to enter this harbor. * * * dging is required at both harbors, but none between them in the r channel, so called, unless there is a surplus of funds after making most needed improvements. Have you no practical and experienced who can be put in charge of the work as inspector?

Very respectfully,

GEO. PARKER.

olonel BLUNT.

OGDENSBURG, ST. LAWRENCE COUNTY, N. Y.,
April 10, 1868.

EAR SIR: Allow me to call your attention to the low state of the er in our lower harbor, viz: Where there was 11 feet one year ago there ow only from seven and a-half to eight and a-half feet, not sufficient th to let vessels of ordinary draught of water come to our wharves with cargoes, thus compelling them to stop out in the stream and lighter r cargoes to the wharves, until the vessel arrives at the draught above tioned, thus incurring a heavy expense and much delay. Now, from fact that at least from four-fifths of the largest vessels which enter port enter at what is called the lower harbor, we think that legiti- e commerce should not be so heavily taxed; therefore we would most ectfully ask that you cause the dredging which is about to commence his harbor to commence at the so-called lower harbor, so as to be the test relief to the greatest number.

C. & D. WHITNEY, JR., & CO.

olonel C. E. BLUNT.

E 7.

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., May 21, 1868.

R: I have the honor to acknowledge the receipt of headquarters r of 12th instant, requesting me to report as to quantity and locality redging done at Ogdensburg last year, &c., &c.

he quantity of material removed by the contractor (and mentioned y letter of 15th April, 1868) was 12,469 cubic yards, as per the surement and daily record of Mr. F. Tunill, the inspector, who, I occasion here to observe, is *entirely reliable and competent*, and I e this remark with a full knowledge of the disgraceful intimations

made to me in Ogdensburg, which may possibly have reached headquarters.

In further reply to the inquiries of headquarters, I believe I can do no better than to transmit the (original) report which Mr. Tunill has made to me in compliance with my call, with a sketch, on which I caused him to mark the places where the dredge worked.

It will be seen from this sketch that the soundings would seem to indicate that no dredging was necessary, except in section marked D; but this is not the only instance in which the soundings shown upon Mr. Judson's map, accompanying General Reese's report, do not, by any means, represent the actual condition of things. My intention was, in view of the low contract price, which would admit of more work than General Reese referred to, (not specifically, however,) to cut a 200-foot channel along shore instead of 100 feet.

The board of June, 1867, of which I was a member, intended, though not explicitly saying so in its report, to leave the determination of the exact limits of the dredging to me.

I do not indicate the increased depths gained by dredging upon the map, as Mr. Tunill distinctly reports that he caused it to be 12 feet, stopping when the dredge struck deeper water.

In connection with this Ogdensburg matter, I respectfully transmit a communication (original) from Mr. George Parker, collector of that port, written in compliance with the request of the board of engineers, to express his views, but which he has sent to me, and which was only received to-day. I believe his opinion to be entirely disinterested, which is more than can be said of many others. It will be seen that he passes by, with a mere allusion at the end of his letter, the channel connecting the old and new (or lower) "harbors."

Very respectfully, your obedient servant,

C. E. BLUNT,
Lieutenant Colonel Engineers, Brevet Colonel U. S. A.

General A. A. HUMPHREYS,
Chief of Engineers United States Army,
Headquarters Corps of Engineers, Washington, D. C.

OSWEGO, *May* 19, 1868.

DEAR SIR: We commenced work September 26, 1867, at point "A," of section No. 1, dredging in a direct line to point "B." After going half the distance found water enough.

Twenty-five and 30 feet near Rome depot we commenced a second cut parallel and *joining* the first, but higher on the Oswegatchie; this we continued until, as before, water enough was found.

The captain of the revenue cutter Chase saying that the vessel pounded on the bottom the winter before, (there being at this time seven feet of water,) and was going out of commission in a few days, to lie at the dock "A," we commenced at the side of the second cut, working south and up the Oswegatchie to the end of dock "A," parallel to and eight feet from dock "A." This we followed with two more cuts parallel to the first.

The fall weather not being such as to admit working in the channel of the Oswegatchie, section No. 4, (beyond the light-house,) on account of the waves on the St. Lawrence, we were compelled to commence work on the next most needed work, although great complaints were made

e millers, because grain vessels could not get in at the Oswegatchie
ıel without lighting.
found a shoal composed of boulders and rocks between the points
ınd "B," extending towards the pier "B," having only three feet
ter, (at point C,) much complained of by tugs, vessels, and the
oats. We had taken three-quarters of this out, when we were
lled to change on account of the dissatisfaction of the contractor
e owners of wharves on the St. Lawrence, the latter fearing that
ıropriation would be spent before they got their channel.
ommenced November 1, on the south line of the St. Lawrence
, section No. 2, at a point opposite the center of the line "A B,"
g down the St. Lawrence to the point "D," where we found quite
ease of water. We then commenced a second cut, as the first
to and further north the width of the cut, which we carried two-
s far as the first, and went into winter quarters December 1, 1867.
edged from September 26 to November 1, when the digging was
081 yards; and from November 1, to December 1, when softer,
ırds. We made 12 feet of water at low-water mark where we

shoal we found one boulder that was too large to bring out, and
of its sinking a vessel, we dug a pit its size and nosed it into it.
ry respectfully submitted.

F. TUNILL.

el C. E. BLUNT.

OFFICE OF COLLECTOR OF CUSTOMS,
DISTRICT OF OSWEGATCHIE,
Ogdensburg, N. Y., May 16, 1868.

EL: There is some discussion and difference of opinion among
nercial and manufacturing men and property owners in our city,
ected by the dredging to be done in this harbor under your
ion.
heard the propositions of different parties having separate
, local, to a certain extent, in their nature and application. I
o given the subject much consideration, and have come to the
conclusion, which I have the honor to respectfully submit for
mination:
with the proposition that the expenditure is for the purpose of
g and improving the *general* commercial and manufacturing
of Ogdensburg—that the law contemplates the expenditure of
y upon the broad principle. Special interests are to be ignored,
permanent benefit of the harbor considered.
he map of the city of Ogdensburg before you, you will see the
Watertown and Ogdensburg railroad passenger and freight depot
rf is located on the west side of the Oswegatchie river, which
into the St. Lawrence at this point.
in a southeasterly direction from the railroad wharf along the
the Oswegatchie river until you come to the bridge; you pass
wharves and a grain elevator. Two large flouring mills and
nufacturing interests of this port are located at and along this
crossing to the easterly side of the river, and following in a
and easterly course until you come to the foot of Isabella street,
several wharves and warehouses, including the ferry wharf.

The channel along this route is not deep enough for vessels of heavy draught to discharge their cargoes without first lightering.

There is a bar also, in a northeasterly direction from the light-house, which is a very serious obstruction to navigation.

The brig Castalia cleared from this port on the 13th of April, 1868, with a cargo of iron ore from the Rome, Watertown and Ogdensburg railroad wharf, went aground on this bar, and was detained some six or eight days before she could be got off, and then not until she was lightered. The detention was attended with great expense, but fortunately the vessel did not receive permanent injury, although at times she was in great danger. I have during the past season seen numbers of vessels aground on this bar, but cannot now call to mind the names of any of them.

There can be no doubt about the existence of this bar, and as it is remote from any particular wharf, but obstructs the entrance to a large number, I think it comes under the general principle and should receive special attention.

Following in an easterly direction from the foot of Isabella street until you come to Elizabeth street, you pass that portion of the harbor which has no wharves or warehouses, and at Elizabeth street you come to the lumber yard wharves; passing on until you reach the grain elevator of the Ogdensburg & Lake Champlain railroad, you arrive at the easterly terminus of the wharves and warehouses of this port. This section of the harbor from Elizabeth street to the grain elevator accommodates the great commercial interest of the Ogdensburg & Lake Champlain railroad and the Northern Transportation Company, which line has at the present time fifteen steamers which are to be increased to twenty-four. The large lumber trade is transacted at this point. The water along this route is not deep enough to discharge cargoes without lightening.

Having called your attention to all the points of commercial and manufacturing interests at this port, will you allow me to remark that the locations are all permanent and cannot be changed.

The water power and manufacturing interests must for all time be located where they are now, at the western terminus of the harbor and the Rome, Watertown, and Ogdensburg railroad.

The business of manufacturing, shipment and transhipment of freight at this point must increase, and the dredging of the bar, to which I have called your attention, and a channel to the wharves is a positive necessity.

At the eastern terminus of the harbor is a steam ferry which connects the Ogdensburg & Lake Champlain railroad with Canada railroads. It is the only practical communication with Canada by means of water navigation during the entire year, on this northern frontier.

There was a preliminary survey made last season for a railroad from Schenectady to Ogdensburg, which developed the fact that the route was perfectly feasible.

The locating survey is to be made this season, and there can be no reasonable doubt as to the early completion of the work. This road, when built, will lessen the distance between the lakes and the St. Lawrence river and the navigable waters of the Hudson, by about one hundred miles; thus giving the route a great advantage over all others for travel, and especially for freight. It will form very nearly an air line from New York city to the city of Ottawa.

The terminus of this road at Ogdensburg will unquestionably be between Isabella street and Elizabeth street, and when this work shall be accomplished it will be necessary to dredge the entire harbor.

In any event the day is not far distant when the unoccupied portion of this harbor will be needed for commercial purposes.

I am, colonel, very respectfully, your obedient servant,

GEORGE PARKER, *Collector.*

Col. C. E. BLUNT,
Engineer Corps, U. S. A.

E 8.

UNITED STATES ENGINEER OFFICE,
Oswego, New York, May 28, 1868.

SIR: I have the honor to acknowledge the receipt of headquarters letter of 26th instant, transmitting copy of preliminary report of the board of engineers, on the subject of the improvement of Ogdensburg harbor, and directing me to carry out the views of the board at the localities "and in the order recommended." There was some discussion by the board as to the wording of paragraph marked "I" in their report, particularly as to the proper mode of referring to the dredging at the northern railroad wharves. It was at first proposed to incorporate with that paragraph the opinion of the board that this work should not be done by the United States, but this opinion was afterwards separately given, and I understood the view of the board to be that I ought to go on work as soon as practicable on the bar and in the river, but that it would be decided at headquarters whether the work at the northern railroad, equally necessary in a certain sense, should be done by the United States. Although the report of the board has been approved, including, I may suppose, this opinion, yet I am still a little uncertain upon this point and therefore respectfully request to be informed as to the intention of headquarters.

Very respectfully, your obedient servant,

C. E. BLUNT,
Lieutenant Colonel of Engineers, Brevet Colonel U. S. A.

General A. A. HUMPHREYS,
Chief of Engineers U. S. A., Headquarters
Corps of Engineers, Washington, D. C.

E 9.

Proceedings of a board of engineers convened at Ogdensburg, New York, by virtue of the following special order.

[Special order No. 82.—Extract.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., June 18, 1868.

II. The board of engineers, consisting of Brevet Major General John Newton, lieutenant colonel corps of engineers; Brevet Colonel C. E. Blunt, lieutenant colonel corps of engineers; Brevet Colonel D. C. Houston, major corps of engineers; Captain A. H. Holgate, corps of engineers, as recorder, convened by special order No. 56 from these headquarters, of the 11th of June, 1868, and which, after meeting at Ogdensburg, as directed, adjourned to await the call of the president, after certain

examinations ordered by them should have been completed, and those examinations having been completed, the board will, as desired by the presiding officer, reconvene at Ogdensburg on the 24th instant for the transaction of such further business as may demand their attention.

* * * * * * *

By command of Brigadier General Humphreys.

THOS. LINCOLN CASEY,
Major of Engineers, Brevet Colonel U. S. A.

OGDENSBURG, NEW YORK,
June 24, 1868—9 a. m.

The board met pursuant to the foregoing order, all being present.

The order reassembling the board and the proceedings of the preceding meetings having been read, the board proceeded to the examination of a map prepared under the direction of Colonel Blunt, embodying the information required by the board in their resolution of May 16, and the preparation of their final report upon the improvement of the harbor of Ogdensburg.

The board has the honor to report that, in addition to the works recommended in its preliminary report dated May 18, 1868, it would recommend the excavation of a continuous channel, 150 feet in width and 12 feet deep at low water, along the river front of the city, connecting the mouth of the Oswegatchie with the waters of the St. Lawrence. This channel is indicated on the accompanying map.

The inner line of the channel should be designated by the city authorities as the line of wharves, and no wharf should be permitted to be erected beyond this line. This line is marked on the accompanying map in yellow and is extended along the entire water front of the city.

The board is of the opinion that this line or a similar one should be laid out by authority of the United States and accepted by the city authorities before any work recommended by this board should be executed. It will be observed that this line cuts off a portion of a wharf at the mouth of the Oswegatchie, which the board consider has had a detrimental effect in deflecting the currents of the Oswegatchie from their natural and proper directions.

The indications, as afforded by the velocities of the currents and the nature of the bottom, make it probable that the in-shore channel, after being dredged to a depth of 12 feet, will gradually fill up, and *should this be the case*, a concave pier, the position and extent of which is given on the accompanying map, would have the effect to maintain the proper depth. Another pier is indicated, joining the first along the east bank of the upper channel, for the purpose of confining the channel and thus increasing the quantity of water passing over the bar. The effect of these two piers is to prevent the dispersion of the waters of the Oswegatchie over the shoal, and confine them to the channels required for navigation. These piers should be constructed where the shoaling of the in-shore channel or the outer bar indicate their necessity for maintaining the required depth.

From all the information which the board has collected by its surveys and from residents, it is of the opinion that the pile pier, such as is used on the Hudson river, is generally if not universally applicable in this instance. A plan and cross-section of this pier is indicated on the accompanying map.

The board considers that the erection of the works herein recom-

peetfully submitted.

JOHN NEWTON,
Lieutenant Colonel Engineers, Brevet Major General.
CHAS. E. BLUNT,
Lieutenant Colonel Engineers, Brevet Colonel.
D. C. HOUSTON,
Major Engineers, Brevet Colonel.
A. H. HOLGATE,
Captain Engineers, Recorder.

E 10.

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., February 6, 1868.

: By your official letter of May 8, 1867, the duties of making sur-
and estimates for a ship canal to connect Lakes Erie and Ontario
d Niagara falls was assigned to me, such surveys and estimates
g been ordered by joint resolution of the 40th Congress, approved
h 22, 1867.

a subsequent letter, I was authorized (in view of the other import-
ities connected with my charge of works of defense and harbor
vements in the eastern district of the lake frontier) to obtain the
competent civil engineers as assistants, and the names of several
given to me. None of these gentlemen having been obtainable,
little delay was caused in consequence, but I at last succeeded in
ging the services of Messrs. James S. Lawrence and Stephen F.
ing, both men of ability and experience in their profession. Field
s were immediately organized under the personal charge of these
emen, and careful transit and level lines run over all the principal
judged practicable for the canal, with such subsidiary and auxiliary
as were necessary in connection with them.

rings have been made wherever previous data and information

or even to state any advantage or disadvantage connected with any particular route. The engineering questions resolve themselves into the item of cost. The commercial ones I do not profess to be particularly competent to discuss, and they involve, moreover, local interests with which an engineer should have no concern; and the military one involved in the greater or less distance of the line from the Canadian frontier is at the same time now so connected practically, as an argument pro or con, with the same local interests, that any expression of my personal views in relation to it would carry with it an *opinion* affecting the location of the canal, which I think I have no right to give. Having in view, also, the provisions of the pending bill before alluded to, I have not felt myself at liberty to consider any but well known systems and plans of canal construction, and have based all my estimates accordingly upon these well known data. Certain projects for an inclined plane, and for a *single lock* or well, to overcome the whole descent at once, have been laid before me by their ingenious originator, but I have not had the time had I felt it my duty to investigate them carefully, and of course cannot take the responsibility of expressing any professional opinion upon them. The dimensions of canal and of locks adopted and used in all the estimates are as follows:

	Feet.
Width of canal at water surface in each cutting	125
Width of canal at bottom in earth cutting	90
Depth of canal	14
Width of canal in rock cutting (sides vertical)	100
Towing-path 6 above water surface and 15 wide.	
Slope when protected by slope walls, 1¼ base to 1 height.	
Earth slopes 1 upon 2.	
Length of lock-chamber	275
Width of lock-chamber	46
Depth over miter sill	14
Lift in general	15 and 16

I have thought it entirely unnecessary and uncalled for to enter into any topographical description of the well known section of country through which the proposed canal must pass, nor do I give any statistics relating to the internal commerce which seems to demand its construction. All these matters are well understood. It is even scarcely necessary to remark in connection with the former subject, that the main difficulties attending the construction of the canal are involved in the descent of the "mountain," the country between that ridge and Lake Ontario being generally level, and canal construction correspondingly simple.

The lines for which estimates are submitted are the following:

No. 1. From steamboat landing at Lewiston, *directly up the mountain* to old Fort Gray, and thence to Schlosser; length 7.05 miles.

No. 2. From Five-mile meadow, below Lewiston, on Niagara river, to Lewiston and Schlosser; length 9.38 miles.

No. 2 A. From a point 1,500 feet south of the steamboat landing at Lewiston, crossing the natural basin in an easterly direction, to the foot of the mountain ridge, thence by line No. 2 to Schlosser; length 7.803 miles.

No. 3. From the mouth of Four-mile creek on Lake Ontario to Schlosser; length 14.43 miles.

No. 4. From Wilson, at the mouth of Twelve-mile creek, on Lake Ontario, to the Niagara river between Cayuga and Tonawanda creeks; length 18.35.

'Lockport, civil engineer, has been in local charge of the surveys
Eighteen-mile creek, or Lockport line, and the line extending to
harbor. They have performed their duties with great energy
lity, and the data upon which the estimates for the various lines
ed, as obtained by themselves and the parties under their imme-
harge, may, it is confidently believed, be fully relied upon.
these preliminary remarks, I submit the following memoirs and
es for each of the routes I have referred to:

No. 1.—LEWISTON LINE.

Length, 7.05 miles; 21 lifts; estimated cost, $12,095,438.)

line commences at a point on the Niagara river about 700 feet
t the steamboat landing, where the bank is bold and 50 feet above
r. It is traced along a depression at the foot of the Lewiston
200 feet in a southeast direction; from thence 3,000 feet along
of the ridge, and crossing the same to the Lewiston and Niagara
ilroad; thence in a southerly direction, ascending the mountain
early at right angles to its face, a distance of 1,400 feet to Fort
35 feet above the river.
Fort Gray the line continues for nearly two miles nearly parallel
iver, passing east of the Roman Catholic seminary and the Lewis-
l Niagara Falls railroad; thence following the valley of Bloody
d a southeasterly course one and a half mile, crosses the Lockpor-
agara Falls railroad about three-quarters of a mile east of Sus-
bridge, at the highest point on the line, the elevation being 352
From this point there is a gradual descent into the valley of Gill
which the line strikes about one mile from the crossing of the rail-
nd follows to its mouth at Schlosser, on the Niagara river, three
bove the falls; the whole distance being $7\frac{45}{100}$ miles.
difference between the surface of water of the Niagara river at
on and the Niagara river at Schlosser is 316 feet. This has been
l into 21 lifts; 20 of 15 feet and one of 16 feet.

an elevation of 302 feet, (which is the elevation of the bottom of the canal from this point to its entrance into the Niagara river at Schlosser.) From the commencement of this level the line continues in thorough cut to its termination; the first three miles to the summit having an average cut of 35 feet, three-fourths of which is rock. A pivot or swing bridge will be required for the railroad crossing at this point. The cutting on the next two miles is lighter and averages 27 feet, one-fifth only of which is rock. The last half mile averages 17 feet cutting and is all earth. Near the river the line crosses the Buffalo and Niagara Falls railroad, which will require a pivot or swing bridge.

A guard lock and dam will be required at the river.

No. 2.—LEWISTON LINE.

(Length 9.39 miles; 21 lifts; estimated cost, $11,128,438.)

This line commences at the Five-mile meadow, two miles north of Lewiston. This meadow has an area of about 30 acres, and is elevated 15 feet above the river, affording facilities for the construction of a basin or harbor at this point. The line is traced from the river bank in a southeasterly direction and ascends to the table-land 1,600 feet from its commencement, and is continued on the same course two miles, over gradually ascending ground to a point east of Lewiston, and near the academy; thence southerly three-quarters of a mile to the foot of the mountain ridge 150 feet above the river. At this point the course is changed to southwest, the line ascending the ridge obliquely one mile to Fort Gray, 330 feet above the river. From Fort Gray the line runs for two miles nearly parallel to the river over undulating and gradually rising ground, passing east of the Roman Catholic seminary and the Lewiston and Niagara Falls railroad to a point near the Devil's Hole; thence along the valley of Bloody Run, and a southeasterly course one mile to the summit, 352 feet above the river, and crossing the Lockport and Niagara Falls railroad, descending gradually for two miles into the valley of Gill creek, along which the line continues to its mouth on the Niagara river, three miles above the falls. The length of this line is $9\frac{34}{100}$ miles.

The difference between the surface of water of the Niagara river at the Five-mile meadow and at Schlosser, three miles above the falls, is 316 feet. This has been divided into 21 lifts, 20 of 15 feet each and one of 16 feet.

Commencing on the bank of the river at the Five-mile meadow with a double lock of 16 feet lift, and a basin of 500 feet in length, the line reaches the slope from the meadow to the table-land, which it ascends by five double and consecutive locks, attaining an elevation of 77 feet and a distance from the river of 2,000 feet. From this point there is a level of one mile over favorable ground to lock No. 7; thence the line continues over similar ground another mile to lock No. 8 at the foot of the south ridge, which it ascends by three double locks; thence with a level of 1,100 feet, a double lock, No. 11, and a basin of 600 feet to the foot of the mountain ridge, attaining an elevation of 181 feet. At this point begins the heavy work, it being necessary to cut deep into the mountain side to obtain secure footing for the walls of locks and basins; the line is carried obliquely up the mountain to Fort Gray by two tiers of four and five double and consecutive locks, with an intermediate basin, to an elevation of 302 feet, being the level of the bottom of the canal to its termination at Schlosser.

From Fort Gray the line continues in thorough cut to its termination.

st half mile having an average cutting of 28 feet, of which four- rock; the next three miles to the summit have an average cutting et, three-fifths of which is rock. At this point the Lockport and Falls railroad is crossed, and a pivot or swing bridge will be l. On the next two miles the cutting is lighter, averaging 27 -fifth of which is rock. The last half mile has an average cut of and is all earth. Near the river the line crosses the Buffalo and Falls railroad, and a pivot or swing bridge will be required. A ck and dam will be required at the entrance to the canal.
ariation of this line see memoir No. 2 A.)

No. 2 A.—LEWISTON LINE.

ength, 7.8 miles; 21 lifts; estimated cost, $11,031,916.)

ne commences at a point on the Niagara river, 1,500 feet south amboat landing, and 53 feet above the water it takes an easterly , crossing a low sandstone ridge into and across the natural a point at the foot of the mountain ridge, one mile from its ement and 150 feet above the river. Here the course is changed west, (and thence the line is identical with the Lewiston line

encing at the river at Lewiston the line ascends the bank by ble and consecutive locks, and is continued by a short level or the sandstone ridge, which it ascends by four double and con- locks to the natural basin; thence across the basin (by a canal ikment, the surface being 121 feet above the river) to its eastern margin, which it ascends by four double and consecutive locks n 600 feet long and 181 feet above the river. (From this point 2 A and line No. 2 are identical.)

No. 3.—FOUR-MILE CREEK LINE.

ength, $14\frac{43}{100}$ miles; 21 lifts; estimated cost, $12,673,520.)

ne commences at the mouth of a creek four miles east of the river on Lake Ontario, and follows the channel of the creek for ; thence in a southerly direction on the table-land, with a gradual ver very favorable ground, eight miles to the mountain ridge, ler's Sulphur spring; thence in a southwest direction to the brow idge, and then turning to the southeast, descending into the Fish creek, which it crosses, and reaches the summit at the end ith mile. Descending into the valley of Gill creek the line follows e to the Niagara river at Schlosser, three miles above the falls, the whole distance $14\frac{43}{100}$ miles.
fference between the surface of water of Lake Ontario, at the f Four-mile creek and the Niagara river at Schlosser, is 316.4 ucting the 0.4 for variation of level, leaves the difference 316 has been divided into 21 lifts—20 of 15 feet each, and one of 16

encing at the mouth of the creek, with a single lock of 16 feet ine takes a southerly course, and at the fourth lock on the second ains an elevation of 46 feet, being the general level of the t this distance from the lake. From this point the ground rises dually to the end of the seventh mile, its formation being e for the economical construction of the canal, and the use of cks, seven of which are used with levels varying from half a hree miles in length. On the eighth mile and with three tiers of

double and consecutive locks, (two tiers of five each and one tier of four,) with two intervening basins, the line ascends the mountain ridge, obtaining an elevation of 302 feet, being the level of the bottom of the canal to its termination at the Niagara river. At the commencement of the ninth mile, the line enters heavy cutting, which increases for one mile until the summit is reached, 77 feet above the bottom of the canal. From this point the descent is gradual and the cutting decreases, so that on the ninth, tenth, and eleventh miles, the cutting averages 60 feet, three-fourths of which is rock. On the twelfth mile the line crosses the Lockport and Niagara Falls railroad, at which point a pivot or swing bridge will be required, and descends gradually with an average cutting in the twelfth, thirteenth, and fourteenth miles of 30 feet, one-third of which is rock.

In the last half mile the line crosses the Buffalo and Niagara Falls railroad (requiring a pivot or swing bridge) and terminating at the Niagara river, with an average cutting of 18 feet, mostly earth. At this point a gaurd lock for the canal and a dam to form a harbor in the Niagara river will be required.

The pond at the mouth of Four-mile creek may be formed into an inner harbor at a moderate expense.

The outer harbor will be formed by two parallel piers of crib work filled with stone, extending into the lake to 15 feet water a distance of 1,000 feet.

This Four-mile creek line coincides nearly with Captain Williams's line No. 2.

No. 4.—Wilson, or twelve-mile creek line.

(Length, $18\frac{35}{100}$; 21 lifts; estimated cost, $13,993,638.)

This line commences at the mouth of the Twelve-mile creek, and following its course about half a mile the line reaches the table-land, and thence in a southerly course for nine and a half miles over gentle rising ground, very favorable for the location of a canal, it reaches the foot of the mountain ridge. At this point the ascent commences, and a second table-land is passed. Continuing a southerly course the line crosses the Pekin road, and half a mile further the summit is reached, the line descending into the valley of Cayuga creek to the Lockport and Niagara Falls railroad. From thence it takes a southwest course along the valley of the creek to Beryholt, nearly on the same course, to its termination at a point on the Niagara river, two miles east of the mouth of Cayuga creek—the whole distance being $18\frac{25}{100}$ miles.

The difference between the surface of water of Lake Ontario at the mouth of Twelve-mile creek and the Niagara river, at the point where this line terminates, is $317\frac{58}{100}$ feet; deducting $\frac{58}{100}$ for variation of levels, leaves the difference 317 feet; this has been divided into 21 lifts, of which 19 will be 15 feet each, and two of 16 feet.

Commencing at the mouth of the creek with a single lock of 16 feet lift and locating two others, one of 16 feet and the other 15 feet lift, with short levels between on the first half mile, brings the bottom of canal to 33 feet, being the general elevation of the ground at this distance from the lake. From this point to the foot of the mountain ridge, a distance of nine miles, the inclination is gradual, attaining an additional elevation of 135 feet, which is overcome by the use of nine single locks. From this point the line ascends the mountain ridge to a second table land at an elevation of 273 feet above the lake, which is overcome by a tier of seven double and consecutive locks. On this table land is a

of half a mile, and then two more double and consecutive locks
feet lift, attaining an elevation of 303 feet, being the level of the
n of the canal from this point to the Niagara river.
m the lake to this point the ground is favorable to an economical
uction of a canal, there being a greater number of *single* locks
n the line No. 3, and less rock excavation than on either lines No.
r 3, in surmounting the ridge; but from this point deeper rock
g is found than on either of the other lines; the greatest depth of
utting being 92 feet, and the average for the first three miles 65
ree-fourths of which is rock. The next two miles average 41
e largest portion being rock. From thence to the river, two and
rd miles, the average cutting is 27 feet, with but little rock. This
osses the two railroads that are crossed by the other lines, for
pivot or swing bridges will be required.
ard lock and dam will be required at the termination of the canal
Niagara river.
direction of this line may be so changed as to reduce the river
tion two miles, without materially increasing the length of the
r the cost of its construction.
pond at the mouth of Twelve-mile creek may be made into a good
r harbor.
exterior harbor will be formed by building two parallel tiers of
rk filled with stone, extending into the lake to 15 feet water, and
nce of 1,000 feet. Considerable portions of the line surveyed
of the mountain ridge being through swamps and woodlands
ry thinly inhabited, it was impracticable to obtain by mere in-
reliable data for estimating the rock cutting. Correct informa-
this point being absolutely necessary as a basis for trustworthy
tes, borings were taken to the rock at short distances along those
n which estimates are made.
ldition to the lines which have been thus described and for which
tes are given, a number of trial lines were examined, but being
less advantageous, estimates have been confined to these now

ill be observed that the "natural basin," near Lewiston, which is
re of one of Captain Williams's notes, has not been made use of
sidered in any of the projects herewith submitted. No advantage
nsurate with the increased cost was thought to be derived from
roduction into the plan. Both of the two shorter routes have
n consequence, carried directly into the Niagara river. They
le in general with those of Captain Williams.

No. 5.—Olcott or eighteen-mile creek route.

(Length, 25,$\frac{28}{100}$ miles; estimated cost, $12,893,170.)

line of survey begins at the head of Olcott harbor on Lake Onta-
miles east from the mouth of Niagara river following the channel
Eighteen-mile creek (the course of which is nearly south and very
for three and seven-eighths miles; then leaving the creek, follows
y diverging somewhat to the west; ascending gradually, reaches
and a half miles the table-land, over which it passes for five and
ourths miles nearly south to the foot of the mountain ridge, when
rs another valley or gulf two and one-eighth miles in length,
g in width from 80 to 300 feet on the bottom, which is gradually
ing, with steep banks on both sides; this is followed to its head,
the mountain ridge is encountered. From the head of the gulf

the line follows a slight depression in the ridge leading, in a tolerably direct course, west of south for four miles to the east end of Beech ridge, thence by an almost direct line nearly southwest to the Niagara river opposite the north end of Tonawanda island, about seven-eighths of a mile north of the mouth of Tonawanda creek, making the whole distance 25 miles, 22 $\frac{34}{100}$ chains. The difference between the ordinary low water surface of Lake Ontario and the Niagara river at Tonawanda we make 320 $\frac{22}{100}$ feet, which has been divided into 21 lifts, 16 of which will be 15 feet each, and five of 16 feet.

By the use of four locks and dams and a comparatively small amount of excavation, the channel of Eighteen-mile creek, for the distance of three and seven-eighths miles, will be in good condition for the use we propose with very little other expense. In the next distance of one and a half miles four locks will be required and generally but one bank, with dams at the locks forming basins from 200 to 400 feet in width. The last of the locks above mentioned will be at the north end of a level about five and a half miles long, so located that for most of its length the excavation will be just sufficient to form the banks. On this level will be required (to pass a branch of the Eighteen-mile creek) the only culvert necessary on the line.

At the south end of this level is located lock No. 9 at the entrance to the gulf, along which are distributed the remaining 12 locks, numbered consecutively from 10 to 21, inclusive, all separate except Nos. 12 and 13 combined, and 20 and 21 also combined.

Lock No. 21 will be at the commencement of the heavy cutting through the mountain ridge, which for the first two miles is mostly solid rock, needing a depth of cutting of 55 feet, over 50 feet of which is rock. From this summit, which is one and a half miles from the head of the gulf, the surface gradually descends toward the southwest to the river; the surface of the rock, dipping more rapidly in the same direction, disappears in about three miles from the head of the gulf.

The dimensions of the canal estimated on is for 14 feet depth of water, 100 feet wide in rock cutting, in earth 90 feet wide on bottom, with slopes (protected by slope walls) of one and a half feet horizontal base to one foot vertical to the top of the towing path; banks of earth, when not protected by slope walls, to be two feet horizontal to one foot vertical. Towing path to be 15 feet wide and berme 12.

The estimate for locks provides for a chamber 275 feet long from angle to angle of mitre sills, 46 feet wide, with 14 feet depth of water on the mitre sills.

In all cases except when locks are combined, provision is made for basins between them not less than 500 feet long. In the two cases when the locks are combined the estimate includes the cost of double sets.

A guard lock with walls 19 feet high to be located in the vicinity of Niagara river, to protect against occasional high water in the river and to allow the water to be drawn out of the canal when necessary for repairs, &c., is included in the estimate. For local crossings, pivot swing bridges resting on a center-piece are estimated, providing for a waterway on each side of 50 feet.

No. 5 (*a.*)—From Tonawanda creek to Buffalo harbor.

(Length, 15 miles; estimate, $11,000,000, in addition to the length and cost of the Olcott or Wilson lines.)

From Tonawanda creek to the south side of Ellicott creek the line adopted for bottom is 14 feet below the surface of water in the same as

for the Erie canal, which is $324\frac{144}{1000}$ feet above the surface of Lake io.

the south side of Ellicott creek a lock of four feet lift is estimated, ost of which is assumed as the same as for the grand lock to be d on the main line near the Niagara river.

m the lock to Buffalo creek the bottom line is 16 feet below the e of Buffalo harbor, $327\frac{759}{1000}$ above Lake Ontario.

estimate includes nothing for deepening Buffalo creek between the where this line intersects it and Buffalo harbor.

re is also appended an estimate of the cost of deepening the Tona- creek from the mouth of Sawyer's creek to the point where the estimated line diverges from the same, the distance being 216

rly all the work required is for excavating a bar which covers a ce of 30 chains in length, the water, except at this bar, generally ing from 18 to 24 feet deep.

re is also submitted an estimate for a canal of the same dimensions he line from Olcott to the Niagara river, diverging from that line 20th mile and intersecting the Tonawanda creek at the mouth of r's, the line following the general direction of the east branch to ction with its west branch, thence by the main channel to the anda.

bottom line being raised four feet above that estimated for the ine, would, if adopted, consequently diminish the quantity of exca- on the main line between the 13th and 20th miles, as follows: excavation, 731,000 cubic yards; rock excavation, 205,000 cubic

additional lockage of four feet would increase the expense $42,120. total estimate on the main line from the 20th mile to the river be dispensed with in case lines above estimated on should be d.

NIAGARA SHIP CANAL, 1867.—ROUTE No. 1.

[From steamboat landing at Lewiston to Schlosser, 7.45.]

Summary of quantities per mile and estimated cost.

Excavation of earth.			Excavation of rock.			Embankment.		
tity.	Price.	Amount.	Quantity.	Price.	Amount.	Quantity.	Price.	Amount.
yds.			*Cub. yds.*			*Cub. yds.*		
3, 469	$0 25	$78, 367 25	58, 730	$1 25	$73, 412 50	70, 000	$0 25	$17, 500
2, 287	25	50, 574 25	1, 346, 499	1 25	1, 683, 117 50	.....	.....	.....
5, 187	25	91, 546 75	392, 581	1 25	490, 726 25	.....	.....	.....
9, 637	25	84, 909 25	470, 128	1 25	587, 660 00	.....	.....	.....
1, 230	25	65, 807 50	611, 771	1 25	764, 713 75	.....	.....	.....
5, 844	25	131, 711 00	260, 437	1 25	325, 546 25	.....	.....	.....
0, 219	25	97, 554 75	116, 645	1 25	145, 806 25	.....	.....	.....
, 883	.....	600, 470 75	3, 256, 791	.....	4, 070, 982 50	70, 000	.....	17, 500

Route No. 1—Continued.

Miles.	Lining and graveling.			Riprap and slope walls.			Bridges.		Locks.		Bailing.*	Totals.
	Quant.	Price.	Am't.	Quant.	Price.	Am't.	No.	Am't.	No.	Am't.		
	Cub.yds.			*Cub.yds.*								
1	5,300	$0 50	$2,650	5,200	$1 50	$7,800	†2	$29,600	‡12	$3,328,560	$3,000	$3,698,089 75
2	2,600	50	1,300	.....	.....	.....	(§)	157,200	‡9	2,496,420	2,000	4,233,411 75
3	2,600	50	1,300	.....	.....	.....	1 com.	6,600	.....	.....	2,000	592,173 00
4	2,600	50	1,300	.....	.....	.....	1 com.	8,400	.....	.....	2,000	684,269 25
5	2,600	50	1,300	.....	.....	.....	†2	27,200	.....	.....	2,500	861,321 25
6	5,100	50	2,550	4,900	1 50	7,350	1 com.	7,000	.....	.....	3,000	477,157 25
7	8,000	50	4,000	10,400	1 50	15,000	‖3	23,800	(¶)	114,415	2,600	403,776 00
	28,800	.....	14,400	20,500	.....	30,750	.....	259,800	.....	5,939,395	17,100	10,950,398 25
To which add for a dam and dredging in the Niagara river at Schlosser												50,000 00
Add also 10 per cent. for contingencies												1,095,039 75
Total												12,095,438 00

*1 common and 1 railroad. †Concrete. ‡2 common and 1 railroad combined.
§Double. ‖Guard-lock. ¶Bailing, draining, and clearing.

NIAGARA SHIP CANAL, 1867.—ROUTE No. 2.

[From Five-mile meadow, by Lewiston to Schlosser, 9.38.]

Summary of quantities per mile and estimated cost.

Miles.	Excavation of earth.			Excavation of rock.			Embankment.		
	Quantity.	Price.	Amount.	Quantity.	Price.	Amount.	Quantity.	Price.	Amount.
	Cub yds.			*Cub. yds.*			*Cub. yds.*		
1	224,042	$0 25	$56,010 50	.....	.....	.....	41,000	$0 25	$10,250 00
2	151,073	25	37,768 25	.....	.....	.....	18,000	25	4,500 00
3	152,290	25	38,072 50	158,557	$1 25	$198,196 25	76,000	25	19,000 00
4	207,913	25	51,978 25	406,996	1 25	508,745 00	74,000	25	18,500 00
5	325,258	25	81,314 50	328,423	1 25	410,528 75	.....	.....	.....
6	396,462	25	99,115 50	500,095	1 25	625,118 75	.....	.....	.....
7	269,692	25	67,423 00	542,560	1 25	678,200 00	.....	.....	.....
8	418,754	25	104,688 50	411,440	1 25	514,300 00	.....	.....	.....
9	435,940	25	108,985 00	185,967	.....	232,458 75	.....	.....	.....
(*)	153,036	25	38,259 00	.....	.....	.....	.....	.....	.....
	2,734,460	.....	683,615 00	2,534,038	.....	3,167,547 50	219,000	.....	52,250 00

*38-100 mile.

Route No. 2—Continued.

Miles.	Lining and graveling.			Riprap and slope walls.			Bridges.		Locks.		Bailing.*	Total.
	Quant.	Price.	Am't.	Quant.	Price.	Am't.	No.	Am't.	No.	Am't.		
	Cub.yds.			*Cub.yds.*								
1	8,100	$0 50	$4,050	$10,600	$1 50	$15,900	3 com.	$13,800	†6	$1,664,280	$2,000	$1,766,290 50
2	10,400	50	5,200	15,100	1 50	22,650	2 com.	9,200	†1	277,380	800	357,498 25
3	6,200	50	3,100	6,900	1 50	10,350	2 com.	9,200	†9	2,496,420	2,000	2,776,338 75
4	3,200	50	1,600	1,200	1 50	1,800	.....	.....	†5	1,386,900	2,000	1,971,523 25
5	2,600	50	1,300	.....	.....	.....	1 com.	6,600	.....	.....	2,000	501,743 25
6	2,600	50	1,300	.....	.....	.....	1 com.	8,400	.....	.....	2,000	735,934 25
7	2,600	50	1,300	.....	.....	.....	‡2	27,200	.....	.....	2,500	776,623 00
8	4,300	50	2,150	3,300	1 50	4,950	1 com.	7,000	.....	.....	3,000	636,088 50
9	6,600	50	3,300	7,800	1 50	11,700	1 com.	5,300	.....	.....	2,500	364,243 75
(§)	5,800	50	2,900	6,100	1 50	9,150	‖2	18,500	(¶)	114,415	1,800	185,024 00
	52,400	.....	26,200	51,000	.....	76,500	.....	105,200	.....	5,939,395	20,600	10,071,307 50
To which add for a dam and dredging in the Niagara river at Schlosser												50,000 00
Add also 10 per cent. for contingencies												1,007,130 50
Total												11,128,438 00

*38-100 mile. †10 common and 1 railroad. ‡1 common and 1 railroad combined.
§Double. ‖Guard-lock. ¶Bailing, draining, and clearing.

NIAGARA SHIP CANAL, 1867.—ROUTE No. 2 A.

From a point on the Niagara river 1,500 feet south of the steamboat landing at Lewiston, crossing at the natural basin, in an easterly direction, to the foot of the mountain ridge; thence by Line No. 2 to Schlosser, 7.603 miles.]

Summary of quantities and estimated cost.

Sections.		Excavation of earth.			Excavation of rock.			Embankment.		
No.	Feet.	Quantity.	Price.	Amount.	Quantity.	Price.	Amount.	Quantity.	Price.	Amount.
		Cub. yds.			*Cub. yds.*			*Cub. yds.*		
1	3,800	261,000	$0 25	$65,250 00	.....	.....	.....	120,000	$0 25	$30,000 00
2	3,500	264,000	25	66,000 00	128,000	$0 25	$160,000 00	.....	.....	.....
3	5,300	207,913	25	51,978 25	406,996	25	508,745 00	74,000	25	18,500 00
4	5,200	325,258	25	81,314 50	328,423	25	410,528 75	.....	.....	.....
5	5,300	396,462	25	99,115 50	500,095	25	625,118 75	.....	.....	.....
6	5,300	269,692	25	67,423 00	542,560	25	678,200 00	.....	.....	.....
7	5,300	418,754	25	104,688 50	411,440	25	514,300 00	.....	.....	.....
8	5,500	435,940	25	108,985 00	185,967	25	232,458 75	.....	.....	.....
9	2,000	153,036	25	38,259 00	.....	.....	.....	.....	.....	.....
	41,200	2,732,055	.....	683,013 75	2,503,481	.....	3,129,351 25	194,000	.....	48,500 00

Summary of quantities and estimated cost, route No. 2 A—Continued.

Sections.		Lining and graveling.			Riprap and slope walls.			Bridges.		Locks.		Bailing.*	Total.
	Feet.	Quantity.	Price.	Am't.	Quant.	Price.	Am't.	No.	Am't.	No.	Am't.		
		Cub. yds.			*Cub. yds.*								
	3,800	2,100	$0 50	$1,050	6,500	$1 50	$9,750	†2	$27,400	‡8	$2,219,040	$2,000	$2,354,490 00
	3,500	2,600	50	1,300	3,300	1 50	4,950	§1	4,600	‡8	2,219,040	2,000	2,457,890 00
	5,300	3,200	50	1,600	1,200	1 50	1,800	.....	.....	‡5	1,386,900	2,000	1,971,523 23
	5,200	2,600	50	1,300	.....	.....	.....	§1	6,600	....	.....	2,000	501,743 25
	5,300	2,600	50	1,300	.....	.....	.....	§1	8,400	....	.....	2,000	735,934 25
	5,300	2,600	50	1,300	.....	.....	.....	†2	27,200	....	.....	2,500	776,623 00
	5,300	4,300	50	2,150	3,300	1 50	4,950	§1	7,000	....	.....	3,000	636,088 50
	5,500	6,600	50	3,300	7,800	1 50	11,700	§1	5,300	....	.....	2,500	364,243 75
	2,000	5,800	50	2,900	6,100	1 50	9,150	‖1	18,500	(¶)	114,415	1,800	185,024 00
	41,200	32,400	.....	16,200	28,200	.....	42,300	....	105,000	....	5,939,395	19,800	9,983,560 00
which add, for a dam and dredging in the Niagara river at Schlosser													50,000 00
ld, also, 10 per cent. for contingencies													998,356 00
Total													11,031,916 00

* Bailing, draining, and clearing. † 1 common and 1 railroad. ‡ Double.
§ Common. ‖ 1 common and 1 railroad combined. ¶ Guard lock.

NIAGARA SHIP CANAL, 1867.—ROUTE No. 3.

[From Four-mile creek to Schlosser, 14.43 miles.]

Summary of quantities per mile and estimated cost.

Miles.	Excavation of earth.			Excavation of rock.			Embankment.		
	Quantity.	Price.	Amount.	Quantity.	Price.	Amount.	Quantity.	Price.	Amt
	Cub. yds.			*Cub. yds.*			*Cub. yds.*		
1	173,861	$0 25	$43,465 25	.....	.....	.....	26,000	$0 25	$6,
2	173,171	25	43,292 75	.....	.....	.....	57,000	25	14,
3	175,368	25	43,842 00	.....	.....	.....	61,000	25	15,
4	43,533	25	10,883 25	.....	.....	.....	178,000	25	44,
5	105,886	25	26,471 50	.....	.....	.....	50,000	25	12,
6	189,584	25	47,396 00	.....	.....	.....	.....	.....	.....
7	143,330	25	35,832 50	.....	.....	.....	39,000	25	9,
8	149,527	25	37,381 75	53,914	$1 25	$67,392 50	162,000	25	40,
9	325,713	25	81,428 25	887,662	1 25	1,109,577 50	.....	.....	.....
10	379,772	25	94,943 00	1,166,233	1 25	1,457,791 25	.....	.....	.....
11	457,571	25	114,392 75	806,327	1 25	1,007,908 75	.....	.....	.....
12	410,770	25	102,692 50	437,575	1 25	546,968 75	.....	.....	.....
13	521,500	25	130,375 00	203,732	1 25	254,665 00	.....	.....	.....
14	542,951	25	135,737 75	103,121	1 25	128,901 25	.....	.....	.....
(*)	234,316	25	58,579 00	1,480	1 25	1,850 00	.....	.....	.....
	4,026,853	.....	1,006,713 25	3,660,044	.....	4,575,055 00	573,000	.....	143,

* 43-100 mile.

Summary of quantities per mile and estimated cost, route No. 3—Continued.

Miles.	Lining and graveling.			Riprap and slope walls.			Bridges.		Locks.		* Bailing.	Tot
	Quantity.	Price.	Am't.	Quantity.	Price.	Am't.	No.	Am't.	No.	Am't.		
	Cub. yds.			*Cub. yds.*								
1	7,300	$0 50	$3,650	9,100	$1 50	$13,650	†1	$4,600	‡2	$531,015	$2,500	$605,
2	9,300	50	4,650	12,900	1 50	19,350	†1	4,600	§1	174,665	800	261,
3	10,100	50	5,050	14,500	1 50	21,750	†1	4,600	§1	174,565	800	265,
4	10,900	50	5,450	16,000	1 50	24,000	†1	4,600	.....	.....	400	89,
5	10,900	50	5,450	16,000	1 50	24,000	†1	4,600	.....	.....	800	73,
6	10,400	50	5,200	15,100	1 50	22,650	†1	4,600	§1	174,665	800	255,
7	10,500	50	5,250	15,200	1 50	22,800	.....	.....	§1	174,665	800	249,
8	4,800	50	2,400	4,300	1 50	6,450	†1	4,600	‖14	3,883,320	3,000	4,045,
9	2,600	50	1,300	.....	.....	.....	†1	6,400	.....	.....	4,000	1,202,
10	2,600	50	1,300	.....	.....	.....	†1	7,000	.....	.....	3,000	1,564,
11	2,600	50	1,300	.....	.....	.....	†1	7,500	.....	.....	3,000	1,134,
12	2,600	50	1,300	.....	.....	.....	¶2	25,000	.....	.....	3,000	678,
13	6,900	50	3,450	8,400	1 50	12,600	.....	.....	.....	.....	3,500	404,
14	6,400	50	3,200	7,400	1 50	11,100	†1	4,600	.....	.....	3,000	226,
(**)	6,200	50	3,100	7,000	1 50	10,500	**1	18,500	(‡‡)	114,415	2,000	208,
	104,100	.....	52,050	125,900	.....	188,850	....	101,200	....	5,227,410	31,400	11,325,
To which add, for Lake Ontario harbor, two piers of crib-work filled with stone, each 1,000 feet long, 20 feet wide, and 18 feet high												175,
Dredging for piers for channel, 1,000 feet × 360 feet × 7.5 feet = 100,000 cubic yards, at 30 cts.												30,
Dam and dredging in the Niagara river, at Schlosser												50,
Add also 10 per cent. for contingencies												1,132,
Total												12,673,

* Bailing, draining, and clearing.
† Common.
‡ 1 16 feet lift and 1 15 f
§ 1 15 feet lift.
‖ Double.
¶ 1 common and 1 railro
** 1 common and 1 railroad combined.
†† 43-100 mile.
‡‡ Guard lock.

NIAGARA SHIP CANAL, 1867.—ROUTE No. 4.

[From Wilson, or Twelve-mile creek, to Niagara river, between Cayuga and Tonawanda creeks, 18.35 miles.]

Summary of quantities per mile and estimated cost.

Excavation of earth.			Excavation of rock.			Embankment.		
Quantity.	Price.	Amount.	Quantity.	Price.	Amount.	Quantity.	Price.	Amount.
Cubic yds.			*Cubic yds.*			*Cub. yds.*		
251,097	$0 25	$62,774 25	.....	.....	.....	57,000	$0 25	$14,250
83,900	25	22,225 00	.....	.....	.....	185,000	25	46,250
194,600	25	48,650 00	.....	.....	.....	8,000	25	2,000
82,500	25	20,625 00	.....	.....	.....	99,000	25	24,750
86,989	25	21,747 25	.....	.....	.....	97,000	25	24,250
134,500	25	33,625 25	.....	.....	.....	30,000	25	7,500
140,490	25	35,122 50	.....	.....	.....	97,000	25	24,250
81,120	25	20,280 00	.....	.....	.....	103,000	25	25,750
103,005	25	25,751 25	.....	.....	.....	103,000	25	25,750
218,694	25	54,673 50	167,218	$1 25	$209,022 50	74,000	25	18,500
416,266	25	104,066 50	936,386	1 25	1,170,482 50	.....	.....	.....
376,545	25	94,136 25	1,324,088	1 25	1,655,110 00	.....	.....	.....
274,094	25	68,523 50	877,343	1 25	1,096,678 75	.....	.....	.....
250,504	25	62,626 00	735,243	1 25	919,053 75	.....	.....	.....
631,209	25	157,802 25	362,119	1 25	452,648 75	.....	.....	.....
914,518	25	228,629 50	57,022	1 25	71,277 50	.....	.....	.....
699,707	25	174,926 75	59,537	1 25	74,421 25	.....	.....	.....
631,146	25	157,786 50	.....	.....	.....	.....	.....	.....
186,054	25	46,513 50	.....	.....	.....	.....	.....	.....
5,761,938	.....	1,440,484 50	4,518,956	.....	5,648,695 00	853,000	.....	213,250

*35-100 mile.

Summary of quantities per mile and estimated cost, route No. 4—Continued.

Lining and graveling.			Riprap and slope walls.			Bridges.		Locks.		Bailing, &c.*	Total.
Quant.	Price.	Am't.	Quant.	Price.	Am't.	No.	Am't.	No.	Amount.		
Cu. yds.			*Cu. yds.*								
9,500	$0 50	$4,750	13,300	$1 50	$19,950	1†	$4,600	3‡	$538,035	$2,000	$646,359 25
10,000	50	5,000	14,200	1 50	21,300	1†	4,600	1§	174,665	500	274,540 00
10,400	50	5,200	15,000	1 50	22,500	.....	.....	1§	174,665	800	253,815 00
10,500	50	5,250	15,300	1 50	22,950	1†	4,600	1§	174,665	1,000	253,840 00
10,500	50	5,250	15,300	1 50	22,950	.....	.....	1§	174,665	500	249,362 25
10,500	50	5,250	15,300	1 50	22,950	.....	.....	1§	174,665	900	244,890 00
10,500	50	5,250	15,300	1 50	22,950	2†	9,200	1§	174,665	500	271,937 20
10,400	50	5,200	15,000	1 50	22,500	1†	4,600	1§	174,665	560	253,495 00
10,500	50	5,250	15,300	1 50	22,950	.....	.....	1§	174,665	800	255,166 25
4,700	50	2,350	4,100	1 50	6,150	1†	4,600	1‖	2,116,325	2,000	2,413,621 00
2,600	50	1,300	.....	.....	.....	2†	11,000	2§	554,760	3,500	1,845,109 00
2,600	50	1,300	.....	.....	.....	1†	4,600	.....	.....	4,000	1,759,146 25
2,600	50	1,300	.....	.....	.....	1¶	20,000	.....	.....	3,500	1,190,002 25
2,600	50	1,300	.....	.....	.....	1†	9,000	.....	.....	3,500	995,479 75
2,600	50	1,300	.....	.....	.....	1†	7,500	.....	.....	3,000	622,251 00
8,100	50	4,050	10,600	1 50	15,900	1†	6,000	.....	.....	3,500	329,357 00
8,800	50	4,400	12,000	1 50	18,000	2†	9,000	.....	.....	3,000	283,948 00
10,900	50	5,450	16,000	1 50	24,000	.....	.....	.....	.....	3,000	190,236 50
5,800	50	2,900	6,100	1 50	9,150	2††	18,500	1‡‡	114,415	2,000	193,478 50
144,100	.....	72,050	182,800	.....	274,200	.....	118,000	.....	4,720,825	38,500	12,526,034 50
To which add for Lake Ontario harbor two piers of crib-work, filled with stone, each 1,000 feet long, 20 feet wide, and 18 feet high											135,000 00
Dredging for piers and channel 1,000′×360′×7.75=100,000 cubic yards, at 30 cents											30,000 00
Dam and dredging in the Niagara river at outlet of canal											50,000 00
Add also 10 per cent. for contingencies											1,252,603 50
Total											13,993,638 00

Bailing, draining, and clearing.
15 feet lift.
35-100 mile.

† Common bridge. ‡ Two 16 feet and one 15 feet lift.
‖ 1 fifteen feet and 7 double. ¶ Railroad bridge.
†† 1 common and 1 railroad bridge combined. ‡‡ Guardlock.

NIAGARA SHIP CANAL, 1867.—EIGHTEEN-MILE CREEK, OR OLCOTT ROUTE, No. 5.

Statement showing by items the estimated cost of each mile and total cost of the whole work.

Miles.	Excavation of earth.			Excavation of rock.			Embankment.		
	Quantity.	Price.	Amount.	Quantity.	Price.	Amount.	Quantity.	Price.	Amount.
	Cubic yds.			*Cubic yds.*			*Cub. yds.*		
1	87,278	$0 25	$21,819 50						
2	30,053	25	7,513 25	17,364	$1 25	$21,705 00	18,000	$0 25	$4,500 00
3	13,307	25	3,326 75	4,440	1 25	5,550 00	15,000	25	3,750 00
4	22,358	25	5,589 50				42,000	25	10,500 00
5	60,994	22	15,248 50				81,067	25	20,266 75
6	120,747	25	30,186 75				73,468	25	18,367 00
7	86,147	25	21,536 75				31,438	25	7,859 50
8	199,218	25	49,804 50						
9	133,671	25	33,417 75				30,725	25	7,681 25
10	126,122	25	31,530 50				6,550	25	1,637 50
11	110,306	25	27,576 50						
12	37,824	25	9,458 00	29,042	1 25	36,302 50	18,000	25	4,500 00
13	90,445	25	5,111 25	101,358	1 25	126,697 50	60,000	25	15,000 00
14	195,784	25	48,946 00	740,494	1 25	925,617 50			
15	196,103	25	49,075 25	1,751,744	1 25	2,189,680 00			
16	873,755	25	218,438 75	427,554	1 25	534,442 50			
17	1,249,913	25	312,478 25						
18	1,244,510	25	311,127 50						
19	1,201,328	25	300,332 00						
20	854,997	25	213,749 25						
21	716,341	25	179,085 25						
22	696,945	25	174,236 25						
23	656,474	25	164,118 50						
24	624,679	25	156,169 75						
25	574,799	25	143,699 75						
(*)	143,266	25	35,816 50						
	10,277,364		2,569,341 00	3,071,996		3,839,995 00	376,248		94,062 00

*22.34 chains.

Eighteen-mile creek, or Olcott route, No. 5 —Continued.

Miles.	Lining and graveling.			Riprap and slope walls.			Bridges.		Locks.		Bailing.*	Total per mile.
	Quant.	Price.	Am't.	Quant.	Price.	Am't.	No.	Am't.	No.	Amount.		
	Cu. yds.			*Cu. yds.*								
1	3,000	$0 50	$1,500	3,300	$1 50	$5,700						$29,019 50
2	2,600	50	1,300	3,200	1 50	4,800	1	$4,600	2	$349,330	$2,000	365,748 25
3	2,600	50	1,300	3,500	1 50	5,250	1	4,600	1	174,665	2,000	200,441 75
4	3,000	50	1,500	5,300	1 50	7,950	1	4,600	2	349,330	1,000	380,469 50
5	7,600	50	3,800	13,000	1 50	19,500	1	4,600	2	356,350	1,000	420,765 25
6	10,900	50	5,450	16,000	1 50	24,000			1	174,665	1,000	253,668 75
7	10,900	50	5,450	16,000	1 50	24,000	1	4,600			1,000	64,446 25
8	10,900	50	5,450	16,000	1 50	24,000					1,000	80,254 50
9	10,900	50	5,450	16,000	1 50	24,000	1	4,600			1,000	76,149 00
10	10,900	50	5,450	16,000	1 50	24,000			1†	13,420	1,500	77,538 00
11	8,600	50	4,300	12,000	1 50	18,000	1	5,500			2,000	57,376 50
12	2,600	50	1,300	4,500	1 50	6,750	1	4,600	8‡	1,253,420	1,000	1,317,328 50
13	2,600	50	1,300	4,100	1 50	6,150	1	4,600	9§	1,428,085	1,000	1,587,943 75
14	2,600	50	1,300				2‖	25,500			7,000	1,008,363 50
15	2,600	50	1,300				1	9,000			12,000	2,261,005 75
16	6,800	50	3,450	7,500	1 50	11,250					10,000	777,531 25
17	10,900	50	5,450	16,000	1 50	24,000	1	8,000			8,000	357,928 25
18	10,900	50	5,450	16,000	1 50	24,000	1	8,000			8,000	356,577 50
19	10,900	50	5,450	16,000	1 50	24,000	1	7,000			8,000	344,782 00
20	10,900	50	5,450	16,000	1 50	24,000					7,000	250,199 25
21	10,900	50	5,450	16,000	1 50	24,000	1	6,000			7,000	221,535 25
22	10,900	50	5,450	16,000	1 50	24,000	1	6,000			7,000	216,686 25
23	10,900	50	5,450	16,000	1 50	24,000	2‖	18,500			6,000	218,068 50
24	10,900	50	5,450	16,000	1 50	24,000	1	5,500			7,000	198,119 75
25	10,900	50	5,450	16,000	1 50	24,000					6,000	179,149 75
(¶)	2,600	50	1,300	2,200	1 50	3,300	2†	19,000	1**	114,415	2,500	176,331 50
	199,800		99,900	283,100		424,659		154,800		4,213,680	111,000	11,507,428 00
To which add for Lake Ontario harbor two piers of crib-work filled with stone, each 1,000 feet long, 20 feet wide, and 18 feet high												135,000 00
Dredging for piers and channel (part rock) 1,000′×360′×7.′5=100,000 cubic yards at 50 cents												50,000 00
Dam and dredging in the Niagara river at outlet of canal												50,000 00
Add also for contingencies												1,150,742 00
Total												12,893,170 00

* Bailing, draining, grubbing, and clearing. † 1 culvert. ‡ 4 single and 4 double combined.
** Guard lock. § 5 single and 4 double combined. ‖ 1 common and 1 railroad. ¶ 22.34 chains.

NIAGARA SHIP CANAL—LINE No. 5 A.

timated cost of constructing a canal diverging from the line surveyed between Olcott and the Niagara river at Tonawanda, at the twentieth mile, nd intersecting the Tonawanda creek at the mouth of Sawyer's creek; naking the same dimensions as estimated on above mentioned line, with urface of water the same as the Tonawanda creek, as used for the Erie nal, being four feet higher than the level of Niagara river at the mouth f the creek—the length of the line being 260 chains.

5,800 cubic yards excavation of earth, at 25 cents	$348,950
8,400 cubic yards slope wall and riprap, at $1 50	72,600
0,600 cubic yards lining and graveling, at 50 cents	15,300
2 common road bridges	12,000
1 guard-lock	112,765
Bailing, draining, and clearing	15,000
Total	576,615

NIAGARA SHIP CANAL.

mated cost of constructing a ship canal between the Tonawanda and uffalo creeks, diverging from the Tonawanda at a point two and one-half iles above its mouth, and intersecting the Buffalo creek at the Union ron Works, about one-half mile above the crossing of Ohio street bridge, the city of Buffalo.

6,600 cubic yards excavation of earth, at 25 cents	$1,639,150
7,200 cubic yards excavation of rock, at $1 25	8,530,800
6,500 cubic yards slope wall, at $1 50	129,750
3,300 cubic yards lining and graveling, at 50 cents	36,600
1 single lock, four feet lift	112,765
24 common road bridges	171,300
5 railroad bridges	70,000
Bailing, draining, and clearing	160,000
Total	10,850,360

timated cost of deepening Tonawanda creek, to provide for fourteen feet epth of water between the mouth of Sawyer's creek and the point where he above estimated line diverges.

000 cubic yards excavation of earth, at 25 cents, $10,000.

NIAGARA SHIP CANAL, 1867.

timated cost of constructing a guard-lock with wall 19 feet high, chamber 275 feet long, 46 feet wide.

,000 cubic yards embankment and lining earth, at 25 cents per yard	$1,000 00
,000 cubic yards puddling, at 12 cents per yard	240 00
,650 cubic yards concrete masonry, at $4 per yard	6,600 00
850 cubic yards masonry in lock wall, at $18 per yard	87,300 00
000 feet, board measure, timber and plank in foundation, at $20 per M	5,280 00

43,000 feet, board measure, white oak in gates and mitre sills, at $75 per M	$3,225 00
47,000 feet, board measure, white pine in lining and gates, at $35 per M	1,645 00
8,500 pounds wrought iron, (besides apparatus for opening and closing gates, filling and discharging locks,) at 15 cents per pound	1,275 00
1,500 pounds cast iron, (except as above,) at 10 cents per pound	150 00
6,000 pounds spikes and nails, at 10 cents per pound	600 00
Apparatus for opening and closing gates	500 00
Gates for filling and discharging water	1,600 00
Bailing, draining, and clearing	5,000 00
Total	114,415 00

NIAGARA SHIP CANAL, 1867.

Estimated cost of constructing a single lock 15 feet lift, 275 feet length of chamber, 46 feet wide, 14 feet depth of water on mitre sill.

12,000 cubic yards embankment and lining earth, at 25 cents per yard	$3,000 00
8,000 cubic yards puddling, at 12 cents per yard	960 00
1,350 cubic yards concrete masonry, at $4 per yard	6,120 00
800 cubic yards rubble, at $6 per yard	4,800 00
8,170 cubic yards masonry in lock wall, at $18 per yard	147,060 00
253,000 feet, board measure, timber and plank in foundation, &c., at $20 per M	5,060 00
30,000 feet, board measure, white oak plank in gates and mitre sills, at $75 per M	2,250 00
38,000 feet, board measure, white pine plank in lining and gates, at $35 per M	1,330 00
5,900 pounds wrought iron, (besides apparatus for opening and closing gates, filling and discharging locks,) at 15 cents per pound	885 00
1,000 pounds cast iron, (except as above,) at 10 cents per pound	100 00
5,000 pounds spikes in foundation, gates, &c., at 10 cents per pound	500 00
4 sets gates for filling and discharging lock, at $275 per set	1,100 00
4 sets apparatus for opening and closing gates, at $125 per set	500 00
Bailing, draining, and cleaning	1,000 00
	174,665 00
Additional cost for lock of 16 feet lift:	
390 cubic yards masonry in lock walls, at $18 per yard	7,020 00
Total	181,685 00

NIAGARA SHIP CANAL, 1867.

ıated cost to construct two piers of double combined locks, (four locks,) h 15 feet lift, chamber 275 feet long, 46 feet wide, 14 feet depth of water mitre sill.

)0 cubic yards embankment and lining earth, at 25 cents per yard	$4,000 00
0 cubic yards puddling, at 12 cents per yard	1,200 00
0 cubic yards concrete masonry, at $4 per yard	19,280 00
0 cubic yards rubble, at $6 per yard	7,200 00
0 cubic yards masonry in lock walls, at $18 per yard	486,540 00
0 feet, board measure, timber and plank in foundation, &c., at 20 cents per foot	11,680 00
0 feet, board measure, white-oak plank, in gates and mitre sills, at $75 per M	6,750 00
0 feet, board measure, white-pine plank, in lining and gates, at $35 per M	4,760 00
0 pounds wrought iron, (besides apparatus for opening and closing gates, filling and discharging locks,) at 15 cents per pound	3,150 00
0 pounds cast iron, (except as above,) at 10 cents per pound	300 00
0 pounds spikes and nails, at 10 cents per pound	1,600 00
for filling and discharging water	3,300 00
atus for opening and closing main gates	1,500 00
g, draining, and clearing	1,500 00
Total	554,760 00

NIAGARA SHIP CANAL, 1867.

ıted cost of constructing a stone culvert of two semicircular arches, 10 feet diameter, resting on bench walls, two feet high.

cubic yards excavation of earth, at 25 cents per yard,	$1,050 00
cubic yards puddling, including materials, at 40 cents per yard	520 00
feet, board measure, timber and plank, in foundation, at $25 per thousand feet	1,400 00
pounds spikes and nails, at 10 cents per pound	100 00
cubic yards masonry in arch, at $15 per yard	6,350 00
cubic yards masonry in bench walls, abutments, &c., at $10 per yard	3,000 00
g, draining and clearing	1,000 00
Total	13,420 00

ectfully submitted.

CHARLES E. BLUNT,
Lieutenant Colonel Engineers, Brevet Colonel U. S. A.

ral A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

E 11.

Harbor at Wilson, New York.

UNITED STATES ENGINEER OFFICE,
Oswego, New York, March 10, 1868.

SIR: In reply to headquarters letter of 27th ultimo, (as further explained by that of 7th instant,) transmitting for report a resolution of the House of Representatives of the 26th ultimo, on the subject of the harbor at Wilson, Niagara county, New York, I have the honor to report as follows:

One of the lines surveyed under my direction for the Niagara ship canal terminates at Wilson, and it became necessary to add to the estimates for the canal proper, one for a harbor at the mouth of Wilson's or Twelve-mile creek. There was no time to make a detailed survey of the harbor, or to study out and make in detail plans for improvements. A map of a previous survey, made at the expense of the United States, which was sent to me from headquarters, September 26, 1867, furnished the information necessary for a general estimate of the cost of piers and dredging.

Although I visited the harbor, I neither made, myself, any inquiries, nor took any steps towards procuring any information upon the subject of the actual or prospective business of the village or present harbor, or its value as a harbor of refuge, with a view to its improvement, at the expense of the United States. I infer, however, that there may be some information on file at headquarters, from the fact that the map sent me September 26, 1867, contains reference letters which seem to involve some report.

I estimate the probable expenditure at this point to make a harbor, in case the canal should terminate there, as follows:

Two piers, each 1,000 feet long, by 20×18 feet, at $60 per running foot	$120,000 00
Dredging between piers and inside, to give a depth of 14 feet, (depth at entrance being now only seven feet,) 100,000 cubic yards, at 35 cents per yard	35,000 00
Total	155,000 00

Of course, if the canal should enter Lake Ontario at the mouth of Wilson's creek, there can be no question as to the necessity of the expenditure of funds by the United States; but in case it should not so terminate, the question becomes an entirely different one, as to which my duties in connection with the canal surveys require no investigation, and I made none accordingly; and it is, therefore, not in my power to communicate any detailed information as to the second branch of the congressional resolution, as to the "importance and propriety of Congress making an appropriation for the improvement of said harbor;" that is, I suppose, independent of the canal question.

If I correctly understand the last paragraph of the explanatory letter from headquarters of the 7th instant, the requirement "to furnish such information as I possess, relative to the importance and propriety, &c., &c.," does not include the expression of my private opinion as to such importance or propriety, and I therefore confine myself to the statement of such facts as I accidentally possess.

1. The United States have never, so far as I am informed, made any expenditures at this point.

2. It is 12 miles east of the Niagara river and six miles west of Olcott, Eighteen-mile creek.) For Olcott Congress has made one appropriation of $60,000, (which will be applied this year in piers and dredging,) and has been asked for another of the same amount; one object of said appropriations being, I suppose, the formation of a harbor of refuge.

3. There is a local business at the harbor which, I doubt not, would be increased and benefited by the extension of the present private piers, and additional dredging.

4. These private piers are about 300 feet long, with a channel of 150 feet. They were built and are now undergoing repair at private expense, and some dredging has been done and more is proposed, also at private expense. I do not think that over seven feet draught can now be carried in.

5. Should Congress judge it important and proper to appropriate money for the improvement of this harbor without reference to the ship canal, I would respectfully suggest an estimate, as follows:

800 feet extension of each pier, 800 feet in all, at $50 per running foot	$40,000 00
Dredging 30,000 cubic yards, at 30 cents per yard	9,000 00
Contingent expenses	1,000 00
Total	50,000 00

Very respectfully, sir, your obedient servant,

C. E. BLUNT,
Lieutenant Colonel of Engineers, Brevet Colonel.

General A. A. HUMPHREYS,
Chief of Engineers, United States Army,
Headquarters Corps of Engineers, Washington.

E 12.

UNITED STATES ENGINEER OFFICE,
Oswego, New York, November 30, 1867.

SIR: As directed by headquarters letter of 28th October, 1867, I have made an examination of the harbor of Port Ontario, at the mouth of Salmon river, Lake Ontario, N. Y., have obtained such statistics and other information as I could, and such profiles and soundings as the lateness of the season would permit, and have the honor to submit my report upon the subject, as required by my instructions. A map of the locality is also submitted. It is based, in part, upon a recent survey which I obtained in the land office at Pulaski, and in part upon levels, measurements and soundings, taken under my own direction. In consequence of the setting in of the fall gales, which have been constant since the receipt of my instructions, and which cause a heavy sea and breakers on the shore in the vicinity, it has been impracticable to procure any soundings except in the river and pond; and one datum, the distance of the fifteen-foot curve from the shore, could not be accurately obtained. This datum and its dependent, the length of the piers required, has therefore been assumed upon information obtained at the harbor, and from Lieutenant Smead's report, hereinafter referred to.

Salmon river is a stream of some considerable magnitude, which enters into Mexico bay, Lake Ontario, about twenty miles east of Oswego. The insignificant, decaying village of Port Ontario, thirty years ago the site of a grand land speculation, is about a mile above its mouth. The river, in its lower portion, is winding, with low, marshy shores, and islets which are covered in freshets, and at the high stage of the lake. Its outlet has probably been more than once changed by the action of the lake upon the flat, sandy shores, and one of these changes has doubtless caused the basin, now called Selkirk pond, which is shown upon the map. The river now enters the lake over a bar about six inches in depth, in a line nearly parallel to the beach, and at right angles to its previous course. At this entrance are still visible the remains of two piers, built, I understand, by the United States twenty-five or thirty years ago, and also an abandoned light-house.

These piers (shown upon the map with this report) do not seem to me to have been very judiciously located, for reasons which cannot be better stated than in the language of a report made September 20, 1836, to Col. J. J. Abert, by Lieut. R. C. Smead, U. S. A. Lieut. Smead, referring, it would seem, to a proposed plan of improvement at this point, which (or something similar) was probably partially carried into execution, says:

> The present entrance would be a very difficult and dangerous one, even if the bars were removed. A vessel coming from the west, before the wind, would be under the necessity of running almost on a lee shore before changing her direction, and then turning 90° to the right, in a space so narrow as to allow no lee way; she would therefore be in imminent danger of going ashore in the act of luffing. The plan submitted by Mr. Hugunin does not remove the evil, but rather increases it, as a vessel could generally shape her course so as to enter the natural mouth obliquely from the northwest, but if improved according to his plan, she must come square in, and turn a right angle in a channel two hundred feet wide, which appears to me to be impossible to be accomplished in safety in a gale from the west, with a heavy sea rolling in between the piers. Indeed, I believe it to be impracticable to make a safe and convenient entrance that shall follow the present channel of the river.

For these reasons, with which my own opinion entirely agrees, I cannot recommend any expenditure whatever at the present entrance of the river

In order to obtain a better entrance to the harbor, it is my opinion that the present outlet of the river should be closed by a dyke, and a new and direct one cut through the narrow sand-spit, or point, which now divides it from the lake.

Appearances seem to indicate ancient outlets through this spit, which have been, as above referred to, closed by the action of the lake, in drifting the fine sand of which the shores in the vicinity seem wholly composed. The sides of this cut, which should be 200 feet wide at least, should be protected by crib-work, and the new channel or mouth dredged out to 12 feet depth at low water. A pier should be carried out into the lake on the prolongation of the south side of this new opening to at least 15 feet depth at low water, which would be, it is believed, 1,000 feet long. A light-house, on a pier-head of sufficient size, will also be absolutely necessary. A north pier is not necessary as a barrier against drift material from the north, but will be needed to confine the current of the river, and assist its action in keeping the channel clear, as well as to give smoother water in entering the harbor. This north pier should not be less than 400 feet in length. The distance between these piers should not be less than 200 feet. Any lesser opening would render the access in gales very difficult. In any case, the entrance can scarcely be so easy as that of Oswego harbor, which is 350 feet wide, and a vessel missing that could scarcely expect to succeed in entering Salmon river, even with an equal width of entrance.

ıe distance between the piers, however, is made greater than 200
e river will not be able to keep the channel scoured out. Indeed,
lieved, from all the appearances and information which can be
that this entrance will require more or less annual dredging to
a sufficient depth of water, and to counteract the tendency of
causes to close all the entrances by bars.
osition of the old piers is favorable to smooth water in the river
and a direct cut with piers into the lake must of course cause a
amount of sea inside when there is a westerly gale.
his reason, and because the channel of the river will not give
ıt space for a harbor, as the plan clearly shows, and to obtain
ıt harbor and anchorage room, the basin called Selkirk pond
be dredged out to at least 10 feet at low water. The river chan-
f will also require some dredging, as appears by the soundings.
these views as the basis of my calculations, viz, the closure of the
channel, cutting a new one at least 200 feet wide through the
it at or near the low place called the "wind-gap," to be dredged
2 feet low water, and protected by crib-work on each side, with two
ı out into the lake in a direction nearly northwest and southeast,
:h pier 400 feet and the south pier 1,000 feet long, the latter pre-
or a light-house or beacon-light; dredging out the channel of the
ar the new cut and between the new piers outside, and dredging
the middle of Selkirk pond, to give at least 10 feet at low water.
imates of cost will be as follows:

ough spit, above low water at narrowest point, called ıd Gap," 11,713 cubic yards of sand excavation, at ıts	$3,513 90
l through spit, 200 feet wide, with 12 feet water, l cubic yards dredging, at 25 cents	6,955 25
ıg outside and between piers 700′×240′×6′=37,100 , at 25 cents	9,275 00
rk to protect sides of cut, 300′×2=600′ long at $25 unning foot	15,000 00
ier 400 feet long, of cribs 30 feet long, 20 feet wide, .5 feet average height, at $50 per running foot, com-	20,000 00
ier, 1,000 feet long, at same prices	50,000 00
ouse Head, 40 feet square	5,000 00
ıg in river 80,500 cubic yards; dredging in Selkirk 309,600 cubic yards=390,100 yards, at 25 cents	97,525 00
ent expenses	1,730 00
al cost of improvement	209,000 00

timate is made of the cost of closing the present entrance, as
ı be done by depositing in it the materials removed in dredging.
fficult to see how this can be materially reduced. The heavy
dredging out Selkirk pond cannot be omitted, if any harbor
to be provided, and it is doubtful whether the width between
s should not be 300 feet instead of 200 feet. At Oswego it is
and the difficulty of entrance will be greater at Salmon river.
th at Charlotte is 300 feet.
the use of tugs at Oswego, it was almost impossible for ves-
eave Oswego harbor with a wind blowing fresh from the west-
This difficulty would be still greater at Salmon river, and there

is not now, nor is likely to be, sufficient business to induce tugs to lie in the new harbor for the purpose of bringing vessels in or out. The facilities for entering Oswego harbor, arising from this use of tugs, are much greater than they were 30 years ago, when Lieutenant Smead's report was written. This remark brings me naturally to the second portion of the report which I am required to make, viz: "the necessity or otherwise of a harbor of refuge in that vicinity, stating statistics of the loss of life and property that may have accrued from the want of such harbor." Before entering into this subject, however, it may not be amiss to give the few figures I have been able to obtain, bearing upon the business of the village of Port Ontario, which is a port of entry.

Value of imports during year ending June 30, 1867.....	$896 21
Duties collected during year ending June 30, 1867.....	154 48

Foreign arrivals 22, coastwise 10. Foreign clearances 6, coastwise 9. The discrepancy between arrivals and clearances is accounted for by the fact that some vessels after reporting at Port Ontario subsequently came to Oswego, for which place, being in the same district, no actual clearance is required.

Presuming the question as to the necessity of a harbor of refuge in this vicinity, I quote from the report of Lieutenant Smead, made September 20, 1836, and before referred to. He says: "From its position, (meaning Mexico bay,) opening to the northwest, from the direction of the prevailing winds, and from the fact that there is no harbor between Oswego and Sackett's Harbor, into which vessels can run in a gale, it is extremely dangerous to the navigation of the lake.

"Vessels driven into it in a west or northwest gale are past all hope of safety; they must inevitably be driven ashore, and that too on a beach so shallow that they ground and go to pieces, some two or three hundred yards from the shore, and the crews almost inevitably perish. Many melancholy instances of this kind have occurred, and many valuable lives been lost for want of a port of refuge on this dangerous coast. In this view of the subject, the improvement at the mouth of Salmon river is a work of the utmost consequence to the lake navigation generally, to say nothing of the smart little places which are springing into existence on its navigable waters, which this improvement, the Watertown and Rome railroad, which will pass near the place, and a rich, fertile country around it, cannot fail to make places of some importance. Its principal value, however, will be as a port of refuge." This reasoning is as good to-day (for sailing vessels) as when it was written, though his anticipations as to the growth of Port Ontario, and other villages, have not been fulfilled. I have obtained from A. D. Harrington, of Selkirk, at the mouth of Salmon river, a statement relating to the loss of vessels in Mexico bay, a copy of which I transmit with this report, and from which it appears that since the old light-house was abandoned, in 1854, twenty-two vessels, with an aggregate tonnage of about 2,200 tons, have gone ashore within 10 miles of Salmon river; sixteen of which vessels were a total loss, with a loss of three lives. Whether the loss of all or any of these vessels would have been prevented, had there been a harbor of refuge at Salmon river, or whether all, or any of them, had previously attempted and failed to enter Oswego harbor, I have not been able to learn. I have endeavored, without success, to obtain from the vicinity of Port Ontario some written expression of the wishes and views of that neighborhood as to the expenditure of public money at this point.

I also endeavored to obtain the views of masters of vessels navigating the lake, a very large proportion of whom are to be found at Oswego

at this season of the year; and it having been generally understood that I wished for some statement upon the subject, the paper herewith, marked P, has been sent to me, from which it would seem that many persons whose opinions may be supposed of value do not realize the necessity of a harbor of refuge at this point.

The map accompanying this report shows the harbor, so called, with the improvements I deem necessary, if it should be decided to make it a harbor of refuge. It shows also in a sub-sketch the position of Salmon river relative to Oswego, Sackett's Harbor, and the east end of Lake Ontario in general.

Respectfully submitted.

CHARLES E. BLUNT,
Lieutenant Colonel Engineers, Brevet Colonel U. S. A.

General A. A. HUMPHREYS,
Commanding Corps of Engineers, Washington, D. C.

APPENDIX F.

Annual report of operations for improving the harbor of Plattsburg, New York, for the fiscal year ending June 30, 1868.

This harbor was not placed in my charge until after the work of rebuilding the upper portion of the breakwater had been completed under the superintendence of Brevet Colonel C. E. Blunt, corps of engineers. $6,000 then remained from the appropriations applicable to this harbor.

The breakwater has been thoroughly rebuilt, yet the harbor is in a deplorable condition, owing to a large deposit of sand, mud, &c., near the wharves, particularly the southern, forming a shoal of sufficient magnitude to seriously interfere with the passage of vessels of even light draught. This deposit was derived principally, I think, from the bank of the government reservation south of the harbor, and was conveyed to its present position in the following manner, viz: heavy southern winds force the water of the lake with great violence against this bank, and form at the same time a local current, which carries with it the soil washed from this bank, along the shore to the northward, until meeting the line of the south wharf it is deflected towards the breakwater, when, encountering the return current from that structure, and also the two lateral currents flowing around either end of the breakwater, neutralization of these forces occurs and the suspended matter is necessarily deposited. A very small percentage of this deposit may be brought in from the lake by the two lateral currents above referred to. The location of the breakwater is somewhat objectionable. A position further to the eastward would have been less liable to produce the evil effects caused by its present situation.

The most efficient and probably the most economical plan for preserving the requisite depth of water, after the same shall have been obtained by dredging, is to protect the bank from which the abrasion occurs by some suitable revetment; for, as long as the removal of this material by the action of the sea is possible, there can be no permanent security against the recurrence of the present difficulty. The revetment of this bank would also preserve the government land which is now rapidly disappearing.

About 1,000 lineal feet of rubble-stone revetment three feet thick, laid upon a slope of one-half, and carried to a height of 11 feet above low water, would be required.

[For diagram see original.]

To meet the increasing commercial interests of this harbor, and to afford protection to the new wharves belonging to the railroad organization, recently built beyond the line covered by the present breakwater, an extension to the northward of about 300 feet seems very desirable and necessary. The cost of this extension at present prices of material and labor would be about $25,000.

It was Colonel Blunt's recommendation, in which I fully concur, that the balance of $6,000, now applicable to the improvement of this harbor, should be at once expended in dredging. This amount being inadequate to obtain the necessary depth of water, I was directed by department letter of May 2 to exercise my judgment as to the propriety of commencing any work until after it was ascertained whether Congress would appropriate an additional sum for this object during its present session. Fearing that the desirable season for dredging might pass before the bill in question should receive the sanction of Congress, and in view of the pressing necessities for some melioration in the condition of the harbor, I decided to advertise at once inviting bids for removing about 12,000 yards of this shoal. A copy of this advertisement, with abstract of proposals received under it, is appended herewith. Mr. Van Insen's offer, being lower than any other, was accepted, and it is hoped that he will enter into contract and commence operations without delay. The removal of 12,000 yards of material from the vicinity of the wharves will greatly increase the efficiency of the harbor, giving to it a depth of about seven feet six inches. This should ultimately be increased to 9 feet, or, better still, 10 feet. The appropriation of $10,000 which is expected from the present Congress will be ample to secure the requisite depth of water in all parts of the harbor, but in order to maintain this depth additional periodical appropriations will be necessary, unless by protecting the bank of the government reservation, in the manner heretofore indicated, this constant source of expenditure shall be prevented.

The amount required for the entire and permanent completion of this work would be as follows:

Dredging	$16,000
Revetment	7,000
Extension of breakwater	25,000
Contingencies	2,000
Total	50,000

Amount to be profitably expended during next fiscal year, $16,000.

Name of collection district, Champlain; nearest port of entry, Plattsburg; nearest light-house, Cumberland Head; nearest fort, Fort Montgomery.

Amount of revenue collected during the fiscal year ending June 30, 1868, $401,877 62.

Four-fifths of the entire commerce of Lake Champlain will be benefited by improving this harbor. Amount of cash received by me during year, $712 38; expended, nothing.

Respectfully submitted.

J. W. BARLOW,
Captain of Engineers, and Brevet Lieutenant Colonel U. S. A.

Abstract of proposals for dredging the harbor of Plattsburg, New York.

Names of bidders.	Names of sureties.	Price if received by the United States in boats.	Price if deposited outside the breakwater in the lake.
1. E. B. Van Dusen, Geddes, N. Y.*	W. H. H. Gere and N. Stanton Gere, Geddes, N. Y.	29 cents per cubic yard of sand.	33 cents per cubic yard of sand.
2. Emory R. Seward, Albany, N. Y.†	James J. Belden and Henry D. Denison, Syracuse, N. Y.	35 cents per cubic yard of sand.	
3. Emory R. Seward, Albany, N. Y.†	James J. Belden and Henry D. Denison, Syracuse, N. Y.	.....	40 cents per cubic yard of sand.
4. Luther Whitney	O. C. Mitchell and Hiram Tracy, Burlington, Vt.	.....	60 cents per cubic yard of sand.

* Contract awarded to this bidder who failed to conclude a contract.
† This bid was afterwards accepted and a contract executed with Mr. Seward.

The above abstract is correct.

J. W. BARLOW,
Captain of Engineers and Bvt. Lieut. Colonel U. S. A.

To contractors for dredging.

UNITED STATES ENGINEER OFFICE,
Burlington, Vermont, June 5, 1868.

Sealed proposals will be received by the undersigned until the 27th instant for the immediate removal of about 12,000 yards of sand from the shoal now existing between the breakwater and the wharves of the harbor of Plattsburg, New York. The material excavated will be measured in the boats under the direction of an agent of the government, and will be conveyed by the persons who perform the dredging beyond the breakwater and deposited in the lake, or be received by the United States as soon as placed in the boats. Bids for performing this work in either manner are solicited. The proposals will be opened at 12 m., and bidders are invited to be present. Proposals must be in duplicate, guaranteed, and made out according to prescribed forms, blanks for which may be obtained at this office. They should be indorsed, "Proposals for dredging harbor of Plattsburg," and addressed to

J. W. BARLOW,
Brevet Lieutenant Colonel U. S. A.

F 1.

Annual report of operations for improving the harbor at Burlington, Vermont, for the fiscal year ending June 30, 1868.

The improvement of this harbor is to be effected by adding to the present breakwater an extension of 1,500 feet in a northerly direction, thus protecting those wharves which are now exposed to the action of south, southwest, and west winds, and at the same time increasing the capacity of the harbor. The location and form of the new breakwater was settled in June, 1867, by a board of engineers consisting of the following members, viz: Brevet Brigadier General Hartman Bache, colonel of engineers, Brevet Brigadier General George Thom, lieutenant colonel of engineers, Brevet Colonel C. E. Blunt, lieutenant colonel of engineers.

The board assembled at Burlington, Vermont, on the 15th June, 1867, and after consideration of the subject, reported as follows:

The position of the breakwater shall be from the north end of the old breakwater, on a line, in about 29 feet of water, parallel with the general direction of the shore, until it meets a line drawn from about the middle of the wharfage to Rock Point. That the mode of construction of the breakwater shall be by crib-work ballasted with stone, the cross-section of which shall be rectangular, with a base of 30 feet and a height of 40 feet.

This report was approved by the chief of engineers, and by letter of June 17, 1867, Colonel C. E. Blunt was directed to carry the plan proposed by it into effect.

The charge of this work was transferred to me by Colonel Blunt, by letter of December 12, 1867, in obedience to engineer orders No. 133, dated Washington, December 4, 1867, and soon afterwards the drawings, papers, and funds relating to the work were turned over to me in compliance with the same order. The design for the cribs, recommended by Colonel Blunt, was in accordance with the decision of the board, being 30 feet by 40 feet by 80 feet, to be constructed with square timber, formed and bolted together, and divided into compartments about nine feet square. The flooring of 3-inch plank to be placed five feet above the lower course of timber. The cribs to be filled above the floor with stones of specified dimensions.

Before transferring the charge of the work to me, Colonel Blunt had perfected all the necessary contracts, except that for the timber, &c. But it was expected by the department that L. B. Platt, of this city, the successful bidder for this class of material, would execute the contracts then in his hands, under the supervision of Colonel Blunt, who had already adjusted with Mr. Platt all necessary preliminaries. Mr. Platt's continued delay, much beyond the time allotted to him for closing his business, awoke the anxiety of the department, more particularly so since the previous working season had been lost by the failure on the part of contractors to complete contracts which had been awarded to them. By department letter of December 23, 1867, I was directed to give attention to the perfecting of contracts that were not already completed under Colonel Blunt's last advertisement for this work. Nothing further than to continuously urge Mr. Platt to execute his contract with Colonel Blunt could be done by me under this order, until, having become at last satisfied that he would probably fail to conclude a contract under his proposal, I notified the department by letter of January 15, 1868, of this continued delay, and of my impression regarding it. By telegraphic order of the 17th of the same month, the matter was placed entirely in my hands, with directions to conclude a contract with L. B. Platt. In reply to this letter, I sent the following letter to the chief of engineers:

BURLINGTON, VERMONT, *January* 17, 1868.

GENERAL: I have the honor to acknowledge receipt of telegraphic order of to-day, directing me to take charge of all transactions relating to the breakwater, and to conclude a contract with L. B. Platt. I infer that this order was given under the impression that L. B. Platt is ready to execute the contract for timber in accordance with the proposals made by him to Colonel Blunt, as follows: 115,000 cubic feet 12 by 12 inches, hemlock, at 12½ cents per cubic foot, in lengths of 32 feet and upwards; 25,000 board measure 3-inch hemlock plank, at $17 per thousand; 33,000 cubic feet, 12 by 12 inches, pine, at 22½ cents per cubic foot; 14,000 board measure 3-inch pine plank, at $25 per thousand.

The three last items of this bill he will contract to furnish as above; the first, however, he now declines to provide for less than 18 cents per cubic foot, giving as a reason the advance in price of that kind of timber, between the dates of his proposal and its acceptance. In lieu of the first item he will furnish, if desired, either of the following:

Hemlock, spruce, pine, or ash, flat timber, 10 inches thick, 6 inches face at small end, in lengths of 32 feet and upwards, at 14 cents per foot; flat timber 12 inches thick, 6 inches face at small end, in lengths of 25 feet and upwards, at 16 cents per foot; round timber 10

inches diameter at small end, at 12 cents per foot; hemlock timber in lenghts of 32 feet and upwards, hewed on three sides, with 12-inch faces, not over two inches sweep in a stick, for 15 cents per lineal foot.

Colonel Platt claims that the advance in price of timber since his proposal was made has necessitated this change.

I respectfully submit these propositions, asking advice as to the acceptance of any of them.

I dislike to deviate from the design adopted by Colonel Blunt, as, from his much more extensive knowledge of the subject than I have, the selection of square timber must have been made for good reasons. If any departure should be made, I think it would be quite as well, for the sake of economy, to build the part under water of round timber. Any change in the kind of timber might affect the other contractors and cause difficulty with them.

Very respectfully, your obedient servant,

J. W. BARLOW,
Captain of Engineers, Brevet Lieut. Col. U. S. A.

Major General A. A. HUMPHREYS,
Commanding Corps of Engineers. Washington, D. C.

January 23, 1868, I received the following letter from headquarters corps of engineers:

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 20, 1868.

COLONEL: Your letter of the 15th instant is received. You will reject all bids for timber for the Burlington breakwater, received under the last advertisement of Brevet Colonel C. E. Blunt, and invite new proposals, specifying clearly the kind, dimensions, and quantity of timber required, and reserving the right to reject any or all bids; the proposals to be made in duplicate, and in accordance with the forms furnished from these headquarters.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Captain and Brevet Lieut. Col. J. W. BARLOW,
Corps of Engineers, Burlington, Vermont.

In compliance with this order I notified L. B. Platt of its tenor, and sent the following advertisement to a number of newspapers in different parts of the country:

Burlington breakwater.

UNITED STATES ENGINEER OFFICE,
Burlington, Vermont, January 23, 1868.

Sealed proposals will be received by the undersigned, until the 20th of February, 1868, at 10 o'clock a. m., for the following timber, viz:

115,000 lineal (or cubic) feet of hemlock timber, 12 inches square, in sticks not less than 22 feet in length; 38,000 lineal (or cubic) feet of white pine timber, 12 inches square, not less than 30 feet in length; 25,000 feet, board measure, of 3-inch hemlock plank; 14,000 feet, board measure, of 3-inch white pine plank; 8,500 treenails, (elm or ash,) 2 feet long and 2 inches in diameter.

Pine, spruce, or ash timber may be delivered in lieu of all or part of the first item of this bill. The whole must be delivered at Burlington, Vermont, before the 1st of July, 1868, and at least one-third as soon as navigation opens on Lake Champlain. It must be of the best quality, perfectly straight, of the exact specified dimensions throughout. No other will be received. The prices named must cover all expense of delivery and preparing for inspection, &c, at such points as may be required. The proposals to be made in duplicate, guaranteed, and in accordance with the prescribed forms, which may be obtained upon application at this office.

The undersigned reserves the right to reject any or all bids, if not deemed satisfactory.

J. W. BARLOW,
Captain of Engineers, Brevet Lieut. Col. U. S. Army.

An abstract of proposals received under this advertisement is appended to this report. The offer of Wells De Graw, of Fulton, New York, being the lowest, he was so notified, and in accordance with the law the contract was awarded to him. He, however, manifested no inclination to enter into contract, and as time wore away I became anxious as to his intention of completing it at all. I feel strongly inclined to believe that

his bid was a sham, made with the view of being bought off by some other bidder. After a good deal of correspondence with him, and many promises on his part, he finally appeared in person on the 12th of March, and formally declined to make good his proposal; finding, as he said, that he would be unable to comply with the terms of his offer. The several bidders next higher were then successively notified; but on account of the lapse of time, all below Messrs. Hart & Jennings declined to enter into contract upon their bids. This firm, who are also the contractors for doing the work, were still willing and anxious to furnish the timber. Their bid for this class of material was therefore accepted, and the transaction receiving the approval of the Chief of Engineers, a contract with these parties was at once effected. This difficulty having been finally adjusted, the work seemed in a fair way of making some progress during the season, and without doubt the proposed work of completing and placing six cribs will be successfully accomplished before the advent of cold weather. Messrs. Hart & Jennings, having the contracts for furnishing timber and performing the work, will carry on these operations to much greater advantage than separate contractors could have done. They have thus far shown much enterprise, and an evident determination to push the work as rapidly as practicable. Two cribs are now well under way, and all the timber and plank required for the season's operations has been already procured and is ready for delivery. The iron and spikes were promptly delivered by Mr. R. N. Gere, the contractor for this material, when called upon, and Mr. Whitney, contractor for supplying stone, is ready to furnish it as rapidly and in such quantities as may be required.

In reply to circular from headquarters corps of engineers, dated June 10, 1868, I have to reply as follows: Additional amount required to complete the proposed extension of breakwater, $243,024 46; amount to be profitably expended during the next fiscal year, $75,000.

The work is situated in the collection district of Vermont, Burlington being the nearest port of entry. The nearest light-house is located upon Juniper island, (except the two small lights upon the ends of the old breakwater.) Fort Montgomery, New York, is the nearest fort. The amount of revenue collected at this port during the last fiscal year was $169,115. Five passenger steamers, two freight or towing steamers, arrive and depart daily during the period of navigation; and 2,500 sailing vessels or barges during the same time.

Amount of cash received, $31,000 44; amount of cash expended, $16,254 66.

Respectfully submitted.

J. W. BARLOW,
Captain of Engineers, Brevet Lieut. Col.

Abstract of proposals for timber, plank, and treenails for constructing the breakwater at Burlington, Vermont.

Name of bidder.	Names of sureties.	Hemlock timber, 12 by 12 inch square, per lineal foot.	White-pine timber, 12 by 12 inch square, per lineal foot.	Three-inch hemlock plank, per M, board measure.	Three-inch white-pine plank.	Treenails.
Asa Reynolds	N. H. Reynolds and L. B. Platt.	$0 24	$0 30	$16 00	$30 00	$0 10 each.
*Wells De Graw	B. F. Wells and C. J. De Graw.	18	22	18 00	30 00	07 each.
*Antoin Poupor	J. M. Humphrey and A. D. Boomhower.	16	40	17 00	40 00	60 00 per M ft.
Alwyn Martin	E. A Martin and H. T. Gaylord.	30	35	20 00	30 00	.....
*Laman T. Richardson	W. J. Baker and Peter Smith.	18	36	18 00	25 00	10 each.
Hart and Jennings, (contractors.)	Geo. Barker and Granville D. Jennings.	24	24	18 00	25 00	10 each.
Luther Whitney	.....	28	38	.....	.....	.....

* These bidders declined to enter into contracts upon their bids.

The above abstract is correct.

J. W. BARLOW,
Captain of Engineers, Brevet Lt. Col. U. S. A.

Abstract of contracts for materials and labor for constructing the breakwater at Burlington, Vermont.

Name of contractors.	Material or labor contracted for.	Price.
R. Nelson Gere	Wrought-iron bolts, per pound	$0 04 $\frac{25}{100}$
R. Nelson Gere	Wrought-iron spikes, per pound	06 $\frac{8}{10}$
Jennings & Hart	Constructing and placing cribs, per M (board measure)	4 37½
Luther Whitney	Stone in cribs, per cubic yard	1 00
Hart & Jennings	12-inch square hemlock timber, per lineal foot	24
Hart & Jennings	12-inch square white pine timber, per lineal foot	24
Hart & Jennings	3-inch hemlock plank, per M (board measure)	18 00
Hart & Jennings	3-inch white pine plank, per M (board measure)	25 00
Hart & Jennings	Treenails, each	10

The above abstract is correct.

J. W. BARLOW,
Captain of Engineers and Brevet Lt. Col. U. S. A.

APPENDIX G.

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minnesota, August 31, 1868.

GENERAL: I respectfully submit the following report of my operations for the fiscal year, beginning July 1, 1867, and ending June 30, 1868, and

brought down to the 31st of August, 1868. The subjects treated of in this report will be arranged as follows:

CHAPTER I.—Statement of amounts appropriated and disbursed, and balances on hand August 31, 1868.

CHAPTER II.—Present condition of river surveys and maps; one plate.

CHAPTER III.—Some general considerations regarding the physical features of these rivers, the improvement of them, and the bridging of them; (all to be more fully treated of hereafter in a special report;) two plates.

CHAPTER IV.—History of the improvement being carried on on the Mississippi river. Contains eight plates.

CHAPTER V.—The same with regard to the Minnesota river.

CHAPTER VI.—Detailed estimates for the improvement of the Wisconsin river, and Fox river line, with map.

CHAPTER VII.—Table of ports of entry, collection districts, and amounts collected during the last fiscal year.

CHAPTER VIII.—A presentation of the public importance of these river improvements, as required by the joint resolution of Congress, approved July 27, 1868.

CHAPTER IX.—Summary of the estimates of funds required for the fiscal year ending June 30, 1870.

CHAPTER I.

Statement of amounts appropriated and disbursed, and balances on hand, August 31, 1868.

For procuring and operating two dredge and snag boats on the Mississippi river, $96,000.

For procuring and operating one dredge and snag boat on the Wisconsin river, $40,000.

For removing snags and boulders throughout the Minnesota river, $37,500.

For survey western and northwestern rivers, (amount allotted to me,) $42,500.

On the 6th of April, 1868, I submitted a general report of all my operations up to that time, with an estimate of means, in some cases reduced from those in my last annual report; but, in the aggregate, increased, because public wants had called for some additional works of improvement not contemplated when that report was made. (See H. Ex. Doc. No. 247, 40th Congress, 2d session.)

My operations during the remainder of the fiscal year, namely, during the second quarter of 1868, were confined to employment of assistants, &c., in office work, and in alterations and improvements on the two dredge and snag boats on the Mississippi river.

The total expenditures during the quarter were as follows:

For expense and survey western and northwestern rivers	$2,962 65
For improving the Minnesota river	1,412 40
Dredge and snag boats on the Mississippi river	4,844 46
Dredge and snag boat on the Wisconsin river	535 00

In order to make a complete showing at the date of this report, and the effect of the recent appropriations by Congress upon my works, I will embrace the months of July and August.

The expenditures in these months were as follows:

For dredge and snag boats on the Mississippi river	$19,126 19
For dredge and snag boat on the Wisconsin river	583 51
For removing snags and boulders on the Minnesota river	8,705 41
For examination and survey western and northwestern rivers	3,308 19

There was allotted to me by the Secretary of War, from the item for rivers and harbors in the deficiency bill, $26,000; and from the remains of a former appropriation for examinations and surveys, $14,000.

Full statement of expenditures since June 30, 1867, *and amount available from each appropriation August* 31, 1868.

	Appropriations for examination and surveys, western and northwestern rivers.	Appropriations for dredges and snag-boats on the Mississippi river.	Appropriations for dredge and snag-boat on the Wisconsin river.	Appropriation for removing snags and boulders throughout the Minnesota river.
Amounts appropriated in 1867	$42,500 00	$96,000 00	$40,000 00	$37,500 00
Amounts allotted from the item for rivers and harbors in deficiency bill 1868	.....	26,000 00	.....	.....
Amount allotted from former appropriation for examinations and surveys 1868	14,000 00	.....	.....	.....
Amount of appropriations	56,500 00	122,000 00	40,000 00	37,500 00
Amounts expended	46,084 81	99,789 26	3,435 47	28,289 15
Amounts unexpended	10,415 19	22,210 74	36,564 53	9,210 85

The amounts remaining unexpended from the above appropriations will all be used up by the 1st of March, 1869.

CHAPTER II.

Present condition of river surveys and maps.

Before giving an account of surveys made during the last fiscal year, I will briefly state what was done in 1866.

The surveys on the Mississippi river in 1866 consisted of an instrumental survey of about 74 miles along the river, either at those points where navigation was most obstructed, or where there were bridges over the river, or at proposed sites for bridges.

This work was plotted on a scale of 200 feet to the inch, and reduced to one of two inches to the mile.

An examination of the Wisconsin and Fox rivers was made by Brevet Major C. R. Suter, captain of engineers. From maps and records of surveys made by the Fox River Improvement Company, estimates were made for increasing the capacity of the present improvement so as to admit vessels of four feet draught; also, estimates to increase it so as to allow boats of six feet draught.

The examination of the Wisconsin showed that a survey of both banks, islands, and bars must be made, and the actual slope of river ascertained, before plans and estimates could be made for its satisfactory improvement.

The work on the Minnesota river consisted of a careful reconnoissance by C. E. Davis, civil engineer, of the river from the Yellow Medicine to

its mouth, a continuous line of levels, and an instrumental survey of all points requiring improvement. These surveys were connected with the Land Office surveys. A continuous line of channel soundings was made. This work was plotted on a scale of two feet to the mile, with enlarged plats of localities of bad navigation.

I will now give an account of the surveys, &c., made during the fiscal year ending June 30, 1868.

Surveys and maps of the Mississippi river.

Owing to the continued high water in 1867, but little was done in the way of surveys prior to October 1st.

From the 12th of June to the closing of the river by ice, (November 28,) a party was employed in measuring the discharge of the Mississippi at this point and at Fort Snelling, and of the Minnesota near its mouth. From these observations we are enabled to make an approximate calculation of the discharge at this point during any year in which the reading of the gauge has been recorded, and to determine any other practical question concerning the river, in which the volume of the water or the application of river formulas are important.

A quarter boat, for the use of surveying parties on the Mississippi, was built during the season, the one used in 1866 having been turned over to General J. H. Wilson, at Le Claire, Iowa.

Field-work commenced on the Mississippi river on the first day of October, and continued until the 21st of November. During this time about 103 miles along the river were surveyed.

Whole number of miles measured was 273; miles of level line, 115. Of the river survey, two miles in the vicinity of Pike island; two miles near Saint Paul bridge; two miles at Pig's Eye island; 10 miles at Beef Slough; one and a half mile at Chimney Rock; one mile at Rolling Stone, and one mile at Guttenburg, were re-surveys of work done in 1866 to determine the change in the bed and banks, and its rate of progress.

The plan upon which these surveys were conducted was the same as that of the survey of the Wisconsin river. (See copy of the instructions in the report of surveys on that river.)

These surveys on the Mississippi have all been platted; those made above the outlet of Lake Saint Croix, on a scale of 200 feet to the inch; those below, on a scale of 400 feet to the inch. This change of scale was found necessary, as it would be impossible to get paper of sufficient width to show the whole valley below Lake Saint Croix on the large scale. The valley frequently, within the limits of our survey, reaches a width of three miles.

These plats have also been reduced to a scale of two inches to the mile, and transferred to one map of the valley on that scale, which extends from the Falls of Saint Anthony to the mouth of the Ohio river, combining on this, with the United States land surveys as a basis, all the information we have obtained.

Besides these surveys, an examination was made from the mouth of the Des Moines to the mouth of the Ohio river, to determine the exact position of the bluffs, and to connect the Land Office surveys of the two sides of the river, which, unfortunately, has not been done, except in seven or eight instances, between Saint Paul and the mouth of the Ohio, when the surveys were made. Much difficulty is experienced in making a map with the Land Office work for a basis, from the fact that each side was surveyed independent of the other, and at different periods. With connections made as often as every 10 miles, we find it impossible to

bring the two plats together without in some places entirely closing the river, and in others making it much too wide. Particularly is this the case below the mouth of the Missouri river, where changes in the course of the river are considerable within a comparatively short time.

Among these changes, those between St. Louis and the mouth of the Missouri might be cited. From surveys recently made, under the direction of the city engineer of St. Louis, it appears that there has been an abrasion of 3,500 feet opposite the mouth of the Missouri since 1862. Major Long says, in his report on the improvement of the harbor of Alton, Illinois: "Since 1852 the mouth of the Missouri has been working its way down stream, and is now at least one mile below where it was at that date." Other changes might be noted, but the above are sufficient to show the impracticability of attempting to make a reliable map of the river from the two surveys, made, as they were, many years apart. Our map, however, will show the true position of the bluffs, which is of great importance in studying the causes that have been operating in the past, and distinguishing them from those now acting.

Mr. I. P. Cotton, civil engineer, has had charge of the Mississippi surveys during the past year, and labored assiduously in bringing them to their present state.

Surveys and map of the Wisconsin river.

The survey of the Wisconsin river, under Brevet Major C. R. Suter, captain of engineers, was commenced August 26, and finished November 5.

Whole length of river surveyed, 119.3 miles; number of miles measured, 362.6; miles of level line, 197.

The manner of conducting this, and all surveys under my charge, is fully explained in the following instructions:

Instructions for surveying the Wisconsin river.

UNITED STATES ENGINEER OFFICE,
St. Paul, Minnesota, August 10, 1867.

The survey of the Wisconsin river will extend from Kilbourn City to its junction with the Mississippi. It is designed to have the maps and report exhibit all the information required for a thorough consideration of the subject of improving its navigation at low stages, and determining the best plan of executing it. If this improvement may be made by deepening the water on the bars by means of scrapers in excavating, or by wing and longitudinal dams to prevent such bars from forming, or cause their removal when formed; if by closing up one or more of the channels we can produce a sufficiency in the desired one; or, if these must fail and resort be had to slack-water by dams with locks, or by continuous canal with locks along the valley, must also be determined, if possible, from the survey; and also the relative advantages of different methods in economical construction and practical value, when made.

The quality of navigation sought is such as will adequately meet the wants of a great line of communication from the Mississippi river to Lake Michigan along this river, the upper Fox river, Lake Winnebago, lower Fox river, and Green bay. The existing information contains but very little that is conclusive concerning the engineering question involved. Nothing. therefore, must be relied on from other sources than this survey, and nothing left undone that circumstances of time and ability will enable the surveying parties to do.

The general features of the valleys of the northwestern rivers must be always kept in mind by the different engineers employed, and they are readily appreciated by reference to the following section and map. [For diagrams see original.]

The main features observable are, first, a high bluff on each side of the river valley, from five to ten miles apart, and from 100 to 400 feet high, composed mainly of horizontally stratified rock; and in the case of the Wisconsin, of magnesian limestone of the silurian formation. The slopes, however, are often covered with earth and green grass, so that the rock is discernible to common observation only at places where quarries have been opened.

The sand feature is a level or nearly level terrace mainly composed of sand, though occasionally having a rich surface soil. Towns are frequently located upon it. This terrace is

from 20 to 60 feet above the level of the water. It is never continuous throughout the valley on either side, and rarely of much extent on but one side at a time. It is, probably, the shallow parts of an ancient watercourse which once occupied the valley from bluff to bluff. It is now generally above overflow.

The third feature is the bottom lands of the river, generally overflowed at highest stages, and having the high bluff or terrace for their margin. This bottom contains many lakes and marshes, and is cut up by sloughs forming islands. These islands sometimes divide the main stream into nearly equal parts. The margins of these bottom lands are, in the natural state, generally wooded, and form the banks of the stream at moderate stages when the sand-bars are covered.

The fourth feature is the bed of the stream, which includes the part covered at medium stages, but large portions of which become dry sand or gravel bars at very low ones.

There are thus four different prominent benches or levels in the river valley:

1. The level forming the main bluff.
2. The sand terrace generally above overflow.
3. The bottom land generally overflowed at highest water.
4. The bed of the stream.

It is desirable that the topographical survey should give the limits of each of these and their relative elevation. This may be in a very general way for all but the fourth level, to which the details of the survey should be mainly directed.

The sketch of the valley given above assumes a simple case when the river is divided by a single island, but the bottom lands are often much more complicated in structure. There is generally, however, as in the case given, one main channel, and to this the more thorough work of sounding may generally be confined. Experience, good judgment, and a knowledge of a special case, when it occurs, must govern the engineer as to what is to be done.

The survey will be conducted as follows:

A continuous transit line will be carefully measured and staked off on one bank or the other of the main river, as may be most easy, and all the topography sketched along it. The opposite shore must be located by triangulation across.

The topographical note-book must show both edges of the bottom land, and the edge of the water at the time must fix the position of the stakes used by the sounding parties, and locate all prominent buildings by measurements, angles, or bearings, when practicable.

When passing prominent points marks must be left on which back sights can be taken as the work progresses, and distant points on bluffs and buildings should be similarly used.

Accompanying this transit line must be a careful line of levels, in which should be noted frequently the height of the bottom lands or sand terrace when near, the height of the water of the river at the time, that of the last high water, and the most noted high or low-water mark that may be ascertained.

Both these instrumental surveys should establish marks, at least once a mile, on trees, rocks, or permanent buildings; carefully describe them in the notes, and select such as may be readily found after the lapse of years for future surveys to connect with, as well as for the detached portions of this same survey.

There will be, besides this main line, two subordinate compass parties to survey the minor channels, who will connect their work as often as possible with the main line, and must always do so at the point of beginning and ending of such subordinate line.

These parties will note, besides, the topographical sketches and horizontal dimensions, the height of the banks, either bottom land or sand terrace, wherever they see them, and an occasional section made by sounding across the slough or chutes they are surveying.

In case one of these parties is surveying a channel as large or nearly so as the main channel, it must be sounded with the same care as the main channel, especially if there is any question about which one it would be most desirable to close up.

There will be a separate level party to run level lines transversely of the valley as often as the progress of the survey will permit, and where the steep bluffs are, the hand level can be used to level up to their summits. In all cases side distances for locating important objects must be measured with a tape line; pacing will frequently ascertain them with sufficient accuracy, and if circumstances prevent this, the estimated distance must be noted. The sketches must be made to a scale on the ground, must give the kind and quality of the trees, marshes, sand-bars, and rocks; and when objects cannot be entered on the page by using the regular scale, the distance must be noted or estimated by angles or bearings from fixed points. Connections will be made as frequently as may be with the railroad line, and all the bridges and piers will be carefully measured and located, and notes made of all obstructions.

The sounding lines will be run obliquely across the stream from 300 to 600 feet apart, more or less closely as the correct understanding of the river bed may require. The soundings will be taken by a pole at as nearly uniform intervals of time as practicable, with the boats rowed at uniform rates of speed, and practice must be acquired so that the same line can be sounded forth and back with approximately the same result. Occasionally it would be well to sound them both ways, especially at important points.

Where the grounding of the boat prevents the boat reaching the shore, the distance to the stake on the shore must be noted. The sounding pole should be uniformly 12 or 15 feet long, and "no bottom" recorded where this will not reach.

he cadence of time is lost by changing one pole for another or for a sounding line at
places. These deep holes must be determined separately after the regular lines are
ded. The engineer in charge of the sounding party must keep a sketch of the river and
sounded, and locate, as far as he can with his eye, the position of the bars beneath the
r.

intervals of about each 10 miles there should be two sections 200 feet apart carefully
ded. and a series of floats at mid-depth observed for velocities, so that the discharge can
curately computed after the manner it is now being done at St. Paul

possible the main line should be kept platted as the survey proceeds, on the scale of 200
o an inch, so that no confusion can occur in the system of lines kept in the note-books.
ort time in the evening, and times of bad weather, will suffice for this. It will, besides,
at once to show the directing engineer if the surveys made leave out any desired informa-

The quarter-boat is designed of ample size to furnish convenience for this work.

the quarter-boat, whenever it is lying still, a gauge should be set up and the rise and
f the river carefully noted. It will be of service, in connection with the regular river
es, in reducing the levels to an uniform stage of the river during the time of the survey,
at the slope can be constructed for any stage observed.

procuring subsistence for the parties the quantities allowed per man will not exceed
lowance for a soldier in the armies of the United States. And the material procured
be confined to articles thus allowed, unless an equivalent of other materials can be
ned at an equal or less cost than these.

is directed that no regular meal should be served on the quarter-boat in the middle of
ay, and arrangements must be made for sending a sufficiency of food from the boat to
lace where the parties are at work. Small parties working at some distance from the
must take this meal with them in the morning. In the evening a full dinner meal will
rved on the quarter-boat, and also in the morning before going to the work; and every
se of authority must be used that this does not delay the commencement of the day's

e following party, beside the principal engineer, will be employed on this survey; but
ngineer in charge is authorized to change the men from one to another in any manner
inks best, according to the nature of the work of each: For main transit party, one engi-
and six men; for main level party, one engineer and three men; for cross-section level
, one engineer and three men; for two compass parties, each one engineer and three
; for one sounding party, one engineer and five men; cook and steward, two men; care
arter-boat, two men.

e engineer in charge will endeavor to inform himself fully of the character and resources
e country for building dams of stone, timber, or brush, and for locks and other masonry.
nust also keep a regular journal, detailing the operation of the different parties and other
mation.

e survey will be conducted in the manner above described from Portage to the mouth,
if, on arriving at the latter point, it should be found that additional surveys were required
pecial localities, as undoubtedly it will be, detached parties may be made to execute

weekly report of progress will be made to this office, and further information given from
to time if required.

The surveys were completed according to these minute directions, and laborious work of plotting them was mainly performed by Captain W. Wellman, chief engineer, Captain W. W. Rich, chief engineer, and R. J. Dukes, civil engineer.

All the surveys on this river have been plotted on a scale of 200 feet he inch, making 24 sheets each 10 feet long, and these plots reduced he scale of two inches to the mile.

The office work has all been conducted by Captain D. W. Wellman, ted States civil engineer; Major Suter having been assigned to other ies.

Surveys and maps of the Minnesota river.

n examination of the Minnesota river was made in 1867 from Lac ers to its mouth, to determine the character of the bottoms, the tion of the terraces, and main bluffs.

ie results of this examination have all been put on the map of the r made in 1866, and the whole valley represented in great detail on ale of two inches to a mile. All the surveys on the Minnesota, and construction of the maps, have been by or under the direction of C. Davis, civil engineer.

Surveying outfit.

This consists now of two large flat-boats, fitted up for quarters for surveying parties, and about 25 small row-boats and skiffs, the whole being perishable material, and having cost the appropriation about $7,000. These will answer to prosecute the surveys on the Mississippi and its tributaries, if they are continued, till all important surveys are finished; and there will, in addition, be required for the Mississippi, above the rapids, a small steam propeller, costing about three thousand dollars, ($3,000.)

Additional surveys required.

It is believed that no further surveys will be required on the Minnesota and Wisconsin rivers, except it may be in some limited spaces, to supply information on some point whose importance became known by the survey already made, and not known before.

There is a necessity for completing the survey of the Mississippi, so as to make a continuous map of it from the Falls of Saint Anthony to Rock Island rapids, and it is best to occupy two years in doing it, because part of it will admit of this delay; and in the end it will be more economical, as better enabling us to use up and wear out our outfit, and not require an increase of our present one. There should not be less than thirty thousand dollars ($30,000) for this Mississippi survey in the coming year and for finishing the maps afterward. The examination and survey of the Mississippi above the falls will require ten thousand dollars, ($10,000.)

There is also a memorial before Congress in relation to rivers and harbors under my supervision, that requires a survey of the Chippewa river, of the St. Croix river, and of the harbor at Alton. I think there will be required for the Chippewa river ten thousand dollars, ($10,000;) for the St. Croix, five thousand dollars, ($5,000.)

There are also some additional measurements required to complete the collection of material on the subject of bridging the Mississippi between St. Paul and St. Louis, and completing the maps and diagrams illustrating it, requiring six thousand dollars, ($6,000.) There is an absolute necessity for this, in order to complete this important subject and present it to Congress. This matter has greatly increased in magnitude since the passsage of the general law in relation to bridging the Mississippi, and these bridges may be a fruitful source of litigation and trouble hereafter, requiring the amplest information to settle.

I have not included the survey and improvement of Alton harbor in my estimates, as it does not come regularly within my field of duties.

It should be considered, in judging of the importance of these surveys, that these northwestern rivers have not been surveyed and mapped before; that on all of them public works of improvement are needed and solicited by the people, and that no engineer nor legislative body can properly consider the necessity for improvement, nor the means required to effect it, till the surveys and maps are made. It is only by surveys that an engineer can assemble the facts, subject them to analysis, and comprehend the physical laws governing the stream it is proposed to operate upon.

Good maps and profiles and measurements have the further advantage, that every other engineer can from them readily prepare such plans as his own experience may suggest, or test the soundness of those submitted to him. These things, when properly done, require much time, and even if the works of improvement should, from necessity, be sus-

ed, the surveys should by all means be kept going on, so that when nprovement is again resumed full knowledge will be at hand to it. Besides the injury to the material on hand by suspending the ys, there will be lost the valuable experience acquired by the assist- by their having to seek a livelihood in other fields. The special rements for a proper river surveyor are not generally met in the ary engineering experience. Nothing shows the necessity of these ys more than the fact that we are unable yet to submit our definite in many cases, because the maps of the surveys are still incom- ; and much of that failure that may be seen to have attended former improvements arises solely from imperfect preparatory surveys, and sequent attempt to improve where there was no knowledge of the producing the obstructions and the means of counteracting them.

CHAPTER III.

general considerations regarding the physical features of these rivers, improvement of them, and the bridging of them, all to be more fully ted of hereafter in a special report.

NERAL CONSIDERATIONS REGARDING THE PHYSICAL FEATURES OF THESE RIVERS.

this I will first treat of the prominent physical features of the rivers I have examined and studied. This part of my report is based not upon what I have done the past two years, but also upon my exam- ns on the Missouri river and its tributaries in 1855, 1856, and 1857, eport of Secretary of War, accompanying President's message to ress, in December, 1858.) The subject connects itself intimately certain features of the great lakes, and, in fact, of the whole con- t of North America. It will necessarily be treated of at some length, et I shall only present some of the leading features, leaving out the itude of detailed surveys and determinations which have brought y conclusions.

my report made January 21, 1867, (H. Ex. Doc. No. 58, 39th Con- , 2d session,) I showed that the beds of the upper Mississippi river f several of its tributaries were filling up. At that time the expla- n of this was not comprehended by me, and, in order to make the iption of the phenomena easily understood, I made a supposition the excavated valley between the bluffs of the Mississippi had been ted from the ocean already formed, and that the slope and volume of ain stream was not able to keep in motion the materials which the aries to this great central trough of the continent brought into it. re is nothing material to be changed in that description. And gh it is true, as I have since found, that the portion of this great h below Savannah has been submerged beneath the level of the of Mexico since it was first cut out, yet, as a whole, this supposi- ould not explain the filling up now going on above this point. much examination of the rivers, and study and comparison of all cts ascertained with the observations on other rivers and the Lake ipeg basin, the conclusion was reached that Lake Winnipeg was ontinuous southward, covering the central portion of the valley Red River of the North, and having its outlet down the Minnesota and not, as now, down the Nelson river to Hudson's bay.

en the northern outlet formed and the southern one ceased, the

filling up of the ancient bed began, as we now see it to be going on. The river banks near the old outlet show that this change took place since the glacial period. The ancient Lake Winnipeg was larger than the present Lakes Superior and Michigan combined.

In seeking for a hypothesis to explain how this change of outlet was brought about, that of a gradual change of level, depressing the northern and elevating the southern portion of the valley, was the only one that would account for all the facts then known to me, and I was confirmed in this by the investigations made by Mr. Jas. E. Mills along the Atlantic shores, which showed a northern depression to be going on there.

This hypothesis was fortunately one that observations on other lakes enabled me to test, and it is so well supported by them that I regard this northern subsidence no longer an hypothesis but an established fact. (See map accompanying Chapter VI.)

My surveys show that Lake Winnebago formerly had its outlet southward to the Wisconsin river, and since changed to the northward through the lower Fox river into Green bay.

It has long been known that Lake Michigan once had its outlet southward through the Illinois river, and that Chicago stands in the old bed of the lake, the southern shore of which is about 12 miles south of the city. All the small lakes I have had an opportunity to examine indicate the same thing—the leaving of their southern shores and encroaching on their northern shores. All the accounts I have read, and all the maps of the lakes I have consulted, show the same thing.

Even the maps of the northern and southern shores of the continent plainly indicate it. Any one can test the matter of northern depression and southern elevation for himself by examining the published maps, and remembering that the effect of bodies of water on the shore is to abrade it and spread the material smoothly over the bottom, while the effect of the atmosphere is to cut the land up into ridges and to wash the soil from the rocks, so that the land rising from the water will have comparatively smooth outlines and successive lagoons parallel to the shore, while the land going under water will show jagged and sharp outlines, with deep indentations and numerous islands.

I think the map of North America thus indicates an elevation going on south of a line joining Cape Hatteras on the Atlantic with Cape Mendocino on the Pacific, and a depression north of this line. As far as my reading goes, I think the rivers west of the line in the Rocky mountains indicate this also. But confining myself to the rivers east of it, where this northern depression is established, we see that all the rivers whose flow is southward must have their slopes diminishing, while those flowing in the opposite direction must have their slopes increasing. Carrying this thing backward in time, we see that the lake outlets would all be southward, and not northward, as now; and that there is reason thence to infer that Niagara river and the Saint Lawrence river are outlets of comparatively modern origin. It has long been observed that all these northern outlets abound in waterfalls and rapids, and this confirms their recent origin.

But it may be asked, what of the rapids on the Ohio at Louisville, and on the Mississippi at Keokuk, and again at Rock Island? These, which to me at first seemed like a fatal objection to considering rock rapids as indicating rivers of recent origin, proved afterwards to give the most convincing arguments in its favor, for my observations show, in connection with those made by others, that at each of these places the ancient river had a wide and deep bed cut entirely through the rock formations which now obstruct them; that these old channels became silted up after

lleys were cut out, and at a time when the level of the gulf ex-
l up to the points now about 450 feet above its present level.
, the present river courses at the rapids show only the abrasion of
eam since the last elevation; the river not being able to regain its
d, its present course at the rapids is of recent origin.
ight seem a very hopeless task to undertake to locate the time in
ical ages when the Mississippi channel was first excavated, nor
I have ventured to solve so great a problem. But it has come
that my investigations seem to have led direct to that solution.
hese results have such important practical value in the under-
ng of the works for commercial purposes with which I am intrusted,
ure to give an outline of my investigation of this subject here,
hat as I presented it to the meeting of the American Association
Advancement of Science, in Chicago, in August, 1868, although
f time then prevented me from presenting all I had designed to

paper was in substance as follows:
ing been detailed to survey the upper Mississippi, Minnesota, and
nsin rivers, with a view to improving the navigation and construct-
idges which should afford the least obstruction to navigation
able, I have reached result, which, besides being important to the
for which they were sought, are believed to be of general scien-
terest. I was early impressed by the immense excavations made
silurian rocks through which these rivers now flow.
great excavation or trough above the junction of the Minnesota
ississippi rivers is occupied not by the Mississippi river, but by
nnesota river. The bed of the latter, however, for about 110 miles
Big Stone lake is partially granitic, (probably Huronian,) and the
are of drift.
Stone lake occupies 30 miles of this great excavation, and Lac
s about 20 miles. The two lakes are separated by a strip of low
ut a few feet above their level, and which is about 980 feet above
an. This is a deposit made by the infant Minnesota river as it
this great excavation, and during heavy rains it sends its waters
lson's bay as well as to the Gulf of Mexico.
great excavated valley of which we have been speaking is at this
about a mile wide, and the bluffs or sides, composed of boulders
avel, are about 150 feet high.
following map, from a survey by C. E. Davis, civil engineer, ex-
this locality. [For map see original.]
e one inclined to believe that the existing streams lower down in
er acting for a long period of time, would have been sufficient to
ate the valley of the Mississippi, he must admit the insufficiency
se existing here. In fact, these feeble streams, so far from having
this great excavation, are doing all in their power to fill it up.
thward from Lac Travers commences a vast lake basin, extending
nously to the north end of Lake Winnipeg, including this lake,
Winnipegoose, and Lake Manitoba. The greater part of this
t lake bed is now dry, leaving a well defined beach to mark its
r extent. The Red River of the North flows along the lowest line
s bed. The waters of this basin once flowed southward through
innesota river into the Mississippi.
present level of Lake Winnipeg, according to Mr. Hines, is 650
ove the ocean. [See sketch at the end of paper.]
gain cause the waters to flow southward with the present levels
land existing, would require the lake to be raised 330 feet.

It is obvious this could not be done while the Nelson river outlet existed. There is no good description of this outlet, it never being used for a line of communication, but it is known to abound in rapids and falls which seem to show its recent origin. If we suppose the ice of the glacial period to have closed this outlet, such barrier would have given the lake the whole extent of the basin and caused its discharge southward, but this will not account for all the phenomena observed.

A more satisfactory explanation of a change of outlet from a southern to a northern one is, to attribute it to a northern depression of the basin; for this accounts for the fact that Lake Michigan formerly had a southern outlet through the Illinois river, and that Lake Winnebago also had a much greater extent and a southern outlet through the Wisconsin river. The shores of all the lakes show the water to be receding from their southern sides and encroaching upon their northern ones, as such change of level requires.

This northern depression is known to be going on along the Atlantic coast from New Jersey to Greenland, so that it would seem to be continental in its extent; but further consideration has shown me that all the waters of Winnipeg basin, even if they had continued to flow southward, could not have excavated the passage-way now occupied by the Minnesota and Mississippi rivers, and we must go further back in time to reach a sufficient cause.

In doing this, we will first consider the character of the rivers which existed in the periods preceding the glacial epoch.

During the cretaceous period we know that an ocean extended from the present Gulf of Mexico to the Arctic ocean, covering a large portion of the space between the Missouri river and Rocky mountains. At that time the country through which the upper Mississippi now flows was dry land, and its slopes must have sent its waters westward to that cretaceous ocean. As this continent rose this cretaceous ocean disappeared, and the tertiary period began with great fresh-water lakes along the base of the Rocky mountains. Into these lakes the waters of the upper Mississippi region continued to drain westward.

The gradual southwestern elevation of the continent throughout the tertiary period is distinctly proved by the deposits of these tertiary lakes.

The earliest deposits were of least area, and as they become more recent they expand northeastward, and this action continued apparently to the time preceding the glacial epoch. This elevation at the southwest seems to have been in progress from the earliest geological epochs, every contemporaneous formation being found in the mountain regions of the southwest higher than to the northeast.

Preceding the glacial period, then, all the water-courses of the upper Mississippi region were westward and not southward, as now.

Not only the slope of the land but the great folds of the silurian strata compelled the water to this course.

Over a great deal of the region thus drained no rocks more recent than the silurian are found, so that it must have been dry land since the silurian period.

In the immense ages succeeding the time of the silurian oceans, these rocks were exposed to all the atmospheric influences; and we can conceive how they must have been cut up by ravines and valleys encroaching on each other in endless confusion, somewhat as we now see them in the bad lands of Nebraska, but on a grander scale.

Even the hard azoic rocks forming the dry land of the silurian period must have exhibited the most stupendous atmospheric erosions. These pre-glacial erosions can still be distinguished from those made since.

When, then, the glaciers came, it would seem that their work was easy, and they have planed down the whole region, removing silurian strata 500 feet in thickness over hundreds of miles.

The whole upper Mississippi region was the scene of the drift action, and the valleys of pre-existing rivers were filled up and mostly buried out of sight. The existence of a distinct glacial moraine (unmodified) at Warsaw, on the Mississippi, shows that the glaciers were at least that far south.

I have determined the southwestern limit of the glacial drift action to be the Missouri river, from about the 48th down to the 43d parallel of latitude.

The modified drift forms the grand Coteau du Missouri lying on its east bank, and the material extends thence northeastward almost continuously.

From the Missouri river to the Rocky mountains, over a space varying from 300 to 500 miles in width, no drift is found, except that due to local glaciers of the mountains, which in some cases extended for 50 miles east of their bases.

The existence of this space between the Missouri river and the Rocky mountains, free from drift, shows that the form of the continent and seas in the glacial time were such as to produce in the climate relations similar to those which now exist; namely, that the mountains to the west intercepted, as they now do, the moisture from that direction, and that the supply for the Mississippi valley came from the south as now, moved with the winds in a northerly direction as now, and left an arid region such as we now have along the plains east of the mountains.

Since low temperature and moisture combined are required to produce a glacier, it follows that high temperature, or aridity, either of them, would resist their formation and determine their limit.

If high temperature limited them southward, and aridity westward, the limiting line would have taken a northwest and southeast direction, somewhat as the summer isothermal line now does.

The motion of the glacial mass must have been along the line of least resistance; and towards this limiting line, and the glacial scratchings in the northwest show that the glacial motion was southwest.

There, then, on that limit a river must have been formed to carry away the melting water from the glacier, and this limit was the Missouri river, and that was the river formed thereby.

It cut along this glacial limit because all the streams west of it came from the mountains toward it, down the inclined plain, and there their old course was terminated.

We see what lakes must have periodically formed here; what great barriers must have been formed and burst, one after another, and what deluges the lower valley must have experienced.

As the glaciers began to retire to the northeast, as long as the general slope of the plain was towards the glacial mass, successive rivers were marked out by it along its western face; and all have a parallelism and are close to each other, and have short tributaries or parallel branches, if any. They are, besides minor streams, the James, the Big Sioux, the Des Moines, the Iowa, and Cedar rivers; and finally, the Minnesota and the Mississippi, the last of the parallel rivers.

After the lowest line of the continental valley was passed, the glacier would retire, so that the melting water would run directly from it, and so we see all the tributaries of the Mississippi on the east side.

This direction corresponds with that of the pre-glacial rivers, and it is

probable that many of them here washed out and regained their old beds; such as the St. Croix, Chippewa, and Wisconsin rivers, and so their appearance would indicate.

The bend of the great valley along the Minnesota river, between Mankato and St. Paul, being at right angles to the main course of all the parallel glacial rivers, would seem to disprove the formation of this river having taken place along the glacial margin, and it probably is the bed of one of these pre-glacial rivers. It lies here in the proper fold of the silurian rocks to have been formed in an ancient valley, but from St. Paul southward the present course of the Mississippi is cut square across the fold in the rocks, and the glacial action is the only explanation of it.

The manner in which the glacial action produced these excavations was not by abrading the strata with the grinding power of rocks imbedded in the ice, but after the manner in which a block of marble is sawed. The glacier supplied an immense power in the melting water, and into this water it was constantly dropping sharp rocks and sand. The action of falls also played an important part in this operation.

The waters issuing from a lake have little abrading power, for they have comparatively little rubbing material to operate with. Lakes are only drained by abrading effects produced at waterfalls receding up stream.

The waters issuing at the old southern outlet of Lake Winnipeg could make no impression on the granitic bed of the Minnesota. Had this material been soft like the silurian rocks lower down in its course, or like the tertiary and cretaceous rocks through which the Missouri has cut its way, then this part of the valley might have been worn away as the others have been, and we should still have the drainage of all the Winnipeg basin to the southward.

A cut of 400 feet at Big Stone lake would have drained the whole Winnipeg basin, nor would the banks then have been as high as those of the Missouri at the Byrn hills, which are 800 feet above the water of the river. The slope of the Missouri is more than double that of the Mississippi, and hence the water of the Missouri river is several hundred feet higher than that of the Mississippi at points in the same latitude in their upper courses.

An examination of the bluffs along the Mississippi shows that the space between them is, on the whole, quite uniform in width, gradually increasing downward, being about a mile at Big Stone lake, and reaching six to ten miles at Commerce, below which the space widens out to from 40 to 60 miles.

Sometimes the river, as at the "Grand Tower" and at "Le montagne qui Trempe-à-leau," and several other places, is found flowing between bluffs not even a mile apart, but the bluffs on one side or the other are always found to be a detached mass, and the main valley exists there too.

Two remarkable exceptions to this occur at the rapids, one at Keokuk, the other at Rock Island. Without lengthening this paper, as it necessarily would to go fully into an explanation of these, I will state that, after being long puzzled by them, I discovered that the whole valley had been covered with an extension of the Gulf since the glacial period as high up as Savannah or Dubuque. That the silt brought in by the Des Moines river in the one case, and the Iowa and Rock rivers in the other, during this period, filled up entirely the valley cut out by the great glacial river, and that when the land rose again the Mississippi could not at these points regain its old bed, so it had to cut a new one, and this is not yet completed.

The space between the bluffs at these two places has the width the present river requires, and it is so nowhere else in its whole course.

It might be thought that these investigations do not affect the question of improving the navigation of these rivers or bridging them. In removing obstructions, we have two kinds to deal with, such as arose from causes not now operating, and which, once removed, would not recur; and those from causes that are now operating, and which must be constantly recurring until the cause itself is removed. The observations I have made form the basis of a proper appreciation of these causes.

The question of bridging the Mississippi keeps in view largely the action of the stream and the character of its bed. The usual argument, that the scouring action that has been may take place again, must not be applied here till we can separate the observed effects of such agencies as those I have been treating of from those now at work. Instead of probing with an iron rod every inch of the bed before we can determine the practical depth at which firm rock may be reached, we have here established great conclusions which settle the question for all points at once. Perhaps this may be enough to say on the subject, but I will illustrate it by referring to what took place all along the Mississippi when the Winnipeg basin ceased to discharge its waters southward.

The former river which bore along all the sediment brought by its tributaries was gone. Everywhere along its course these tributaries continued to deposit at their mouths the sand and heavy material as before, and there it accummulated till a lake gradually grew above each point of junction. The waters of each lake gradually spread this material down the valley and encroached upon the lake below it, as a delta advances into any body of water into which a stream flows. These lakes were thus gradually filled up, leaving countless delta islands in their place. But Lake Pepin still exists, made by the sands deposited by the Chippewa.

Lac qui Parle and Big Stone lake, on the Minnesota river, are of the same kind.

So is Lac Travers also.*

The depth of water in these lakes is still 50 to 70 feet or more. So that, having thus accounted for their origin, we have in their depth the least measure of the depth of sand above and below them.

There is no need, when we know how this river passage was made, to sound to get the depth of the sand. We know the foundation everything must have that crosses the Mississippi. The exceptional cases at the rapids I have explained.

So far, what I have said is mainly in the way of a demonstration to account for "certain physical features of the upper Mississippi river."

The grandeur of the subject as it expands before us, and as its details come out one after another, I have tried to keep from influencing my observations and my deductions therefrom.

I have given only part of the facts by which my conclusions are reached, and not drawn all the inferences which the facts presented will warrant, but I intend to do both fully if my time will permit.

If there is any credit connected with this subject I do not claim any for myself, for I hardly know how much of what I have said is derived from others. I have consulted some of the most distinguished geologists on the general subject.

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*The observations of Mr. H. Y. Hines show that the south branch of the Saskatchewan nearly flowed down the Assiniboin river, and we have lakes along the ancient bed the same there.

I am particularly indebted to Mr. James E. Mills, of New York, whose investigations of the gradual northern depression going on along the Atlantic coast suggested to me to account for the change of outlet of lake Winnipeg in the manner I have done.

I believe my observations in themselves demonstrate this depression to be going on along the great central valley, so that we are authorized to conclude that it probably embraces the whole continent.

This must effect all the rivers and all the lakes, bays, and oceans around us, and so far as my observation and reading extend, they all give the same proof of it.

It is, however, a field for many observers, and I have ventured this incomplete showing so that others who have the opportunity, and deem it worthy of their efforts, may help along.

I have added a map showing the ancient Lake Winnipeg, and on the same map shown the extension of the Gulf of Mexico, after the glacial period. I do not mean to assert that this northern lake and this extension of the southern ocean disappeared at the same time, but the one cause, namely, northern subsidence and southern elevation, will account for the disappearance of both. [For map see original.]

2. General considerations regarding the improvement of these rivers.

The primary part of this chapter shows that all the rivers under investigation by me, for the purpose of improving their navigation, are in the *troughs* of what was formerly far mightier streams than are now flowing; that the ancient rivers were not only greater in volume, but cut deeper into the bed through which they flow; and that these ancient beds are now silted up many feet deep, from 60 to 100 feet at least.

From the Rock Island rapids upward, all the tributaries on the south side are short and small in volume, and the principal tributaries, viz., the Wisconsin, Chippewa, and St. Croix, are on the north side.

Even the Mississippi itself, above the junction of the Minnesota, is probably a northern tributary to the great *river-trough* which the Minnesota occupies in continuation of that occupied by the Mississippi below their junction—*the one course of the great ancient river.*

It would have been much more convenient, for the purpose of description and investigation, if the Minnesota had received the name of Mississippi. Even the greatness of the river would not have suffered by it; for we can now carry our minds back into the past, to the time when the extreme sources of the Mississippi included those of the Saskatchewan and Mississippi, if not, too, the Peace river, and other streams and lakes now tributary through the Mackenzie river to the Arctic ocean.

The Missinnippi, or Churchill river now, in flood stages sends its waters to Lake Winnipeg. The Missinnippi, singularly enough, is named by the same Indians that named the Mississippi; the name is nearly the same, and has the same meaning, "great water."

When these northern rivers contributed their water to the Mississippi, it brought no sediment along, for all that it contained was left behind in the ancient Lake Winnipeg. The ancient river must have been, like the present one, a clear stream.

With the exception of the Minnesota river, some of whose tributaries come from cretaceous and tertiary rocks, all the rivers above the Rock Island rapids come from the silurian or older rocks, which are mostly covered with drift. They are all clear-water streams except the Minnesota, and it is most instructive to see how different is the action of a clear-

d to dredging out the sand-bars, to wing-dams to cause the water
them out, or to side canals with locks. The Minnesota seems
iat more favorable for dams and locks, particularly in its upper
where there is a granite bed.

AL CONSIDERATIONS REGARDING THE BRIDGING OF THE MISSISSIPPI.

great trough of the ancient Mississippi gradually widens as we
l, and from being a mile wide at St. Paul, becomes 10 miles wide
ouis. Occasionally, as at Trempeleau and Fulton, the high banks
approach much closer together than this would indicate, but
generally a wide low valley separating this detached bluff from
n bluff, on the side opposite that where the river now flows.
laces would furnish the best location for high bridges without
were such required.
are, besides, the two exceptions presented at the rapids where
osite bluffs favor high bridges. The extreme broad, low valley,
r, makes high bridges generally very expensive to construct
approaches to. Draw-bridges have therefore been so far invadopted for railroad bridges across the Mississippi.
iature of the bed as we now find it, from the nature of its formanders it generally impracticable to reach rock foundation for the
nd grillage and piling (some of it of a very rude kind) has been
support the piers. The crossing of the Mississippi by a railroad
which shall not at all obstruct the navigation, is a very serious
king. None yet built can claim to be such. That at Rock
s positively dangerous. Congress has made laws which permit
struction of tolerable structures, but it is believed that in the
se will have to give way to better ones.
therefore preparing this part of my detailed report with great
meet the wants of future legislation; and as there is no pressing
it at this time, will reserve saying anything further on this subthe detailed report is complete. It is time, however, that Conhould designate some branch of the government to see that the

Many questions in relation to scour, suggested by the deposits found, are also disposed of by my general consideration of the subject. For instance, in regard to the contraction of the water-way by piers and embankments, I think we may conclude that the present section of the Mississippi is just of that area which adjusts the force of the current to the resistance of the bed, composed of material deposited by the stream. Any decrease of the section must increase the velocity, and this will scour and deepen the bed, or widen it where not protected, till the original area of section is restored.

We should, then, before building a bridge, be careful to get the extreme discharge at flood stages, and the mean and maximum velocities at that time, and allow, in placing the foundation, for a scour to take place somewhere in the bed proportional to the contraction we subject the section to, and in the inverse ratio of the velocity at the points where the contraction is made, to the velocity at the points left open.

It will be seen from this, that, rock beds admitting of no abrasure, a permanent increase of velocity must attend the contraction of the water-way, and as these beds are only found where rapids and swift currents already exist, such locations for bridges are exceedingly unfavorable to navigation, on account of the swift water rendering the passage of the pier very difficult.

The bed of the river where the bed is sandy readily adjusts itself to the contraction produced by the piers and approaches to the bridge, and the velocity of the current is not much changed in the end. But precaution must be taken by the engineer to allow for the scour in placing the pier foundations, as above explained.

BRIDGING THE OHIO RIVER.

The friends of safe navigation on this river made such strenuous efforts to protect their interests by further legislation in Congress at its last session, that the subject was brought prominently before the notice of our legislators. The chairman of the Senate Committee on Post Offices and Post Roads consulted me on the general subject of bridging that river, &c.

As great point was made of the obstruction to navigation which the Steubenville bridge occasioned, and as no survey or report of the bridge was available to me, I suggested and obtained authority of the chief engineer to make an examination of it. This I did on the 22d of June, making use of the assistants of Mr. W. Milnor Roberts, United States civil engineer in charge of the improvement of the Ohio river. Mr. Roberts also aided me personally in the examination.

The report I made on that bridge, and an estimate of the cost of building a high bridge of 500 feet span for the Ohio, are printed with the committee report No. 168, 2d session 40th Congress. My report shows that a defective location reduces the span of 300 feet which exists, as provided by law, to a practical span of 250 feet for navigation, and that this location might have been avoided. On this, and on my examination of other bridges in the Mississippi valley, was based my recommendation that the supervision of the location of every authorized bridge should be placed in charge of the War Department, so that the provisions Congress has made for the security of navigation might be enforced. A similar provision should be added to the present law regulating the bridging of the Mississippi river.

The banks of the Ohio differ from the Mississippi very materially in their character, being much closer together and favoring continuous high bridges, instead of low ones with draws.

The much greater range from high to low water, 20 feet in the Mississippi, and 50 feet in the Ohio, make continuous bridges much more desirable for the latter.

The slope, too, of the water is much greater, and the bed is composed in the upper part of much coarser material.

Then, too, in low water the Ohio contains frequent shallow boulder rapids with considerable current, and intervening deep pools with but little current.

For the sake of affecting the velocity of the stream as little as possible, and to get places where the current itself does not change its direction in different stages of the river, the pools afford the best location for bridges to accommodate the navigation.

A full presentation and thorough discussion of these relations of the river and navigation to the bridges and railroad transportation must be left for my special report on that subject.

CHAPTER IV.

History of the improvement being carried on on the Mississippi river.—Eight plates.

A somewhat extended discussion of the method of improving the navigation of the river was given in my preliminary report, dated January 29, 1867, (H. Ex. Doc. No. 58, 2d session 39th Congress,) to which I would refer for more detail than I have now time to write. This report is in the main correct, but it has several errors in the printing, and some confusion in the style—I trust excusable in such hastily prepared reports as we are compelled to make upon subjects involving so many considerations. Some of these errors of print are pointed out in my annual report to the Chief of Engineers, accompanying his annual report to the Secretary of War, and will be found among the documents accompanying the President's annual message to Congress, on its assembling in December, 1867. The conclusion I came to in 1866 determined me to recommend the introduction of Long's scraper, because of "the difficulty, uncertainty, and expense which attend the use of dams." I, however, did recommend an appropriation of $10,000 for the purpose of giving dams a trial. Congress appropriated $96,000, according to recommendation, for the construction of two dredges and snag-boats on the Mississippi, and operating them one year, but gave nothing for dams. In the report submitted by me April 6, 1868, to the Chief of Engineers, printed as House Ex. Doc. No. 247, 2d session 40th Congress, I say of the Mississippi river improvement as follows: "Of the appropriation of ninety-six thousand dollars ($96,000) for two dredges and snag-boats, and operating them one year, there remain the two boats purchased, and $20,181 39 unexpended. This money will be needed before the end of the present fiscal year to complete the repairs, changes, and outfit for snagging and wrecking which these boats require, and they will then be rendered efficient for such work. To continue them in service the coming year will require for each, according to the original estimate, $18,000, or for both, $36,000. These boats were found to operate most satisfactorily for the purpose designed. A detailed report of their working will be given along with the other full report of the year's operations to accompany the next annual report. A depth of three feet was secured by them throughout the season. The service they are performing is such that a continuous appropriation is necessary, and the good they accom-

plish is too great to be dispensed with, unless a most desperate want of means should compel them to lie up. Letters from the principal steamboat men navigating the upper Mississippi testify to the great benefit the dredging, or more properly the scraping, produced on the bars; and the result of the past year's work convinces me that these boats can be relied upon to increase the depth over the sand-bars from eight to 12 inches in low stages, which it is safe to say nearly doubles the carrying capacity of the boats now in use. The sand-bars have their shoalest part at the lower edge; deepen suddenly below this, and very gently above, so that an increased depth of one foot will not be found within from 150 to 200 feet above the lower edge. I believe, however, that an increased depth of one foot is as great an alleviation as can be relied upon by scraping, without a disproportionate expense, and in some localities such complications exist in the sand-bars that it will probably be necessary to resort to wing-dams, or jettees, so as, if not to prevent the obstruction forming below, at least to reduce it to a more simple form. Such a case Frenchman's bar, below St. Paul, presented last year. There are cases, too, where the river becomes divided into several channels, none of which afford the same depth as where the river is united, and it is then desirable to close up all but one. Such a case exists above Nininger. There are also cases where small but deep and favorable low-water channels exist, which escape the sand moved at high water and deposited into the main channel, and which need protection at low water from the sand brought into them from the main channel through connecting passages, and also the prevention of the escape of water from them. Such a case is presented at Beef slough. There are also a variety of other cases that could be enumerated, and many that cannot be foreseen, but which must be remedied as they occur. It will be necessary, too, in some places, to protect the banks and islands from abrasure. In all these cases I would use stone, and trees, and brush; the stone furnishing the weight to hold the dam in place, and the trees and brush the bond to keep it together as one mass, and prevent its being removed piecemeal. This combination is also well adapted to collect sand in and around it, and thus increase its stability and effect. I think it was the absence of a suitable bond, like the wood affords, that rendered the dams formerly placed on the sandy portions of the Ohio (independent of any defect of location) so unstable; besides, as a reason for not applying the Ohio experience to the upper Mississippi, there is the great difference in their high-water velocities, which are so much greater on the Ohio.

"The proper method of applying these dams on the upper Mississippi depends upon the peculiarity of the river. Its waters are clear, and there is no mud deposited from it. The bed and bottom are nearly all sand. The bottom lands are overflowed many feet, and their height is just that to which the current will raise the sand as it passes over the bed, and is the same height as the tops of the highest bars, which differ from islands and bottoms only in not having been formed long enough to have produced a growth of trees. The sand is very heavy, composed mainly of silica, with some iron. When stirred up it sinks again very rapidly. It is moved along mainly at high water, and stops as soon as the current slackens, so at low water comparatively little sand is in motion. I am having very careful measurements in progress to determine, better than we now know, the motion of the sand, which in different years presents such a variety of phases. It seems certain that all improvements will have to be made to meet occasions for them yearly as they arise; and besides the dredge-boats we now have, we must have,

at properly chosen localities, large collections of stone ready for use, and barges to be used in connection with steamboats for loading the stone. The brush and trees can be cut at any time they are needed. Estimates cannot now be made of how much money can be advantageously expended yearly on this kind of improvement without some experience in their use. The amounts heretofore estimated for this purpose by me were $5,000 at Wacouta chute and $5,000 at Prescott island. I do not think this amount is sufficient to test the effect of such works, and recommend that the amount be made $25,000. It should, besides, be so appropriated that the engineer can apply it where it may be needed at the time. As an example of the impossibility of saying what should be done beforehand, the case of Prescott island may be given, which in 1867 had by far the best channel on the side that in 1866 it was thought best to close up. A provision should be made in the law authorizing the engineer to close such channels as he thinks best for the public good, so that he will not be stopped by injunctions, and difficulties certain to arise, as they did in the past year in the attempt of the Chippewa River Improvement Company, organized under the laws of Wisconsin, to close the Big Beef slough.

"I feel prepared now to give this plan of closing diverging channels a more extended trial than I did on completing my former report, and wish to have my powers defined in attempting to carry on such work."

I see no occasion now to change the views expressed as above quoted.

The operations of these boats during the months of July and August have been most satisfactory. The river has been fluctuating between two and three-fourths feet and four feet on the shoal bars, and at first stopped the larger class of boats from running.

This low period came on unusually early in the season, and the Caffery and Montana were undergoing repairs and alterations to fit them for snagging. The Caffery was, however, hastily fitted up for scraping and put at work on the bars, and although she had double duty to perform, restored the navigation for the largest boats, and has maintained it ever since. The frequent short rises and falls caused her work to be constantly repeated; and this demonstrates, beyond cavil, her great usefulness. The steamboat owners became so satisfied of this that they solicited and obtained from me the use of an extra scraper I had on hand, to put on one of their own boats and work at their own expense between Keokuk and St. Louis, where the bars had become troublesome to the large boats running in that part of the river, and for which no appropriation had been made by Congress. Though we cannot claim, until experience has shown us how far these boats can benefit navigation in very unsually low water seasons, we may regard them a success, as having enabled the largest steamboats to reach St. Paul two consecutive years, when experience shows that without our dredging they otherwise would have been compelled to lie up, and justifies the recommendations made at the end of this report for means to continue their operations the ensuing year.

The interest which this dredging with Long's scraper has excited in the Mississippi valley has caused me to embody the detailed reports of H. C. Long, United States civil engineer, as a part of this chapter, so that full information will be available for those who may wish to adopt the use of the Long's scraper.

Major H. C. Long, United States civil engineer, has my highest approbation of the performance of the duties intrusted to him, which he has conducted to success against disheartening opposition from skeptical men.

The steamboats Montana and Caffrey were purchased at St. Louis at private sale; for the former $30,000 was paid, for the latter $8,500. Everything relating to them is given in Major Long's report.

An advertisement was made for proposals to sell the government suitable boats, but no satisfactory proposal was received—the only one being for a stern-wheel boat, which we did not deem suitable. After that due notice was given in the papers for proposals to hire boats to the United States, but no offer was made. The course taken was the only one left, as it was too late to build boats for the service in 1867.

Report of H. C. Long, United States civil engineer, on the adaptation of Colonel Long's scraper to the steamboats Montana and Caffrey and operations in 1867, with seven plates.

UNITED STATES ENGINEER'S OFFICE,
Saint Paul, December 31, 1867.

GENERAL: I have the honor to report my connection with the introduction and use of the scraper invented by the late Colonel Stephen H. Long, United States engineers, as follows:

On the 12th of August an arrangement was made with Mr. D. S. Stombs, machinist of this city, for the construction of three of the above scrapers, two of larger dimension, having five cutters, and one smaller, with four cutters, the former to cost $700 each, the latter $666. This arrangement was faithfully carried out by Mr. Stombs and the work delivered as specified.

The accompanying plate, marked No. 1, shows all the details of construction of the smaller scraper. The larger differed in no respect, except at the base of the triangle there were five semi-circular cutters instead of four. The general plan of the whole apparatus will be found to be the same as that recommended in my report to you of December 26, 1866, (see H. Ex. Doc. No. 58, pp 67 to 73,) and is distinctly set forth in the accompanying plates and explanations. (See plates No. 1 and 2.)

PLATE NO. 1.—EXPLANATIONS.

Fig. 1.—Front view of scraper, with the buckets or cutters attached; platted on the scale of four feet one to inch. A B C, triangular frame of scraper of oak, with its bands, braces, bolts, &c. The drag chains are fastened at B and C. D D D D, the buckets or cutters of boiler iron. E, bowsprit of boat, showing position of shears and chain by which the scraper is raised or lowered when operating on the bars.

Fig. 2.—Isometric view of lower part of scraper on same scale as above.

N. B. The same letters refer to the same parts of the scraper in all the drawings.

PLATE NO. 2.—EXPLANATIONS.

(Side view section and details of scraper, scale four feet to one inch.)

Fig. 1.—Side elevation of frame and cutters or buckets. A B C, triangular frame of oak, with its straps, bolts, and braces; D, bucket; E E, bowsprit; G, friction rollers, to facilitate rising and lowering the scraper.

Fig. 2.—Portion of base of scraper frame, showing method of bolting cutters or buckets, D D, to lower beam by their flanges.

Fig. 3.—Section and side view of same.

Fig. 4.—Under side of lower beam, B C, showing position of iron

)k her departure from St. Paul for experimental operations on the
elow on the 5th of the same month, under your personal super-
I witnessed the first experiments with this scraper at Ninienger
enchman's bar, three miles below this city. The successful ope-
of the machine, the facility with which it was handled, being
or lowered to any required depth, was observed and universally
ledged by those on board the Montana, including quite a num-
invited guests. On the 9th October, the Montana left St. Paul
k on the bars below. My connection with the boat was dissolved
time. I shall therefore not attempt any further description of
y successful career, which terminated with her going into winter
's at Dubuque, Iowa, about the 20th November. During the
above mentioned, from October 1 to November 20, the Montana
nstantly at work; no break or accident happened to her scraping
ery which occasioned any delay or interfered with its usefulness,
oving the care with which it had been designed and constructed.
ccompanying plates, Nos. 3 and 4, show correctly the method of
ng the scraper to the Montana, and the general appearance of
d apparatus when ready for work.

PLATE NO. 3.—EXPLANATIONS.

e eight feet to one inch.)
1.—Plan of bow of steamer Montana, showing portion of main
d manner of fastening bowsprit to same, also position of capstan,
falls, and tackle, for raising and lowering scraper.
2.—Section or side view of same. This figure shows the scraper
up and tilted back in convenient position for steamer when
ray running from point to point, engaged in towing or snagging,
hus raised, the scraper does not interfere with the operations or
y business of any steamer to which it may be attached.

PLATE NO. 4.—EXPLANATIONS.

ne sketch in perspective of United States steamer Montana,
g her relative position, and dimensions of scraper and steamer.
inal dimensions of steamer as follows:

charge of the repairs required by the steamer C. J. Caffrey, also to furnish plans for and suspend the smaller scraper to bow of same. This boat arrived at St. Paul from St. Louis on the 12th September, in command, Captain James T. Griffith.

The Montana being comparatively new, in complete order, and a very strong first-class boat required no further work than was necessary to build the bowsprit and attach the scraper.

The Caffrey was about six years old, had been subject to hard usage during the war, and was much out of order. It was necessary to strengthen her bows very materially, in order to enable her to bear the weight of the scraper and the strain of dragging or pulling while operating on the bars; besides, her machiney wanted extensive overhauling and repairs.

The following comprises a list of repairs, executed under my direction, by Mr. Stombs and various machinists and mechanics employed for that purpose.

1. The boiler and hurricane decks were shortened about 13 feet.
2. New flanges and plumber blocks were cast, and entirely new water wheels were put in.
3. All the main deck forward of the hatches was taken up, the defective flooring timber removed, and the whole recalked.
4. The iron sheathing at the bow was removed, the bow recalked.
5. The bits, capstan, and jack-staff removed, the capstan repaired, and connection with the hoisting engine shortened.
6. Cylinder timbers repaired and wedged up, diagonal bracing placed under same on each side.
7. Diagonal bracing introduced between decks, extending midships from boiler stanchions to bow.
8. Hog-chains fastened by clamp to bow, and extending back between decks to boiler.
9. Clamps of oak framed to sides of vessel, near swell of bow, and secured by heavy iron rods extending across boat.
10. Cylinders reset and lined; metallic packing to piston rods repaired, valves to engine and doctor-rod readjusted, and all the machinery of the boat, including "nigger" or hosting engine and doctor, overhauled and cleaned, and many other minor repairs and improvements introduced not necessary to mention in detail. Finally, the timbers for the bowsprit were framed, the scrapers and all other appliances in position, and the C. J. Caffrey reported ready for active service October 29, 1867.

The general dimensions of the Caffrey are as follows, viz: length on deck, 150 feet; width on deck, 30 feet; width across guards, 38 feet front of wheels; depth of hold, 4½ feet; boilers, (two,) 20 feet 6 inches by 3 feet 6 inches, 3 flues in each; engines, (two,) 5-feet stroke, 15 inches diameter of cylinder; tonnage, 288 tons, custom-house measurement; draught, light, 28 inches; ditto, light, 32 inches, with water in boilers and 20 cords wood on board.

The accompanying plates, 5 and 6, show the method of attaching the scraper to the Caffrey. It will be observed to differ in a few particulars from that on the Montana. The timbers of the bowsprit are lower and carried further back, and but one cross-piece introduced. We were enabled to effect this improvement by altering the position of the capstan and shortening the connection with the hoisting engine, before alluded to.

PLATE NO. 5.—EXPLANATIONS.

(Section of steamer Caffrey, from bow to near center of boilers, on a scale of eight feet to one inch.)

it to be understood that the adaptation of the Long's scraper
ontana and Caffrey, and the mechanical arrangement by which
d and lowered, is not considered the best that could have been
but the one by which we could most readily operate with this
son.

wsprit E E, plate No. 7, can be built in the frame of the boat,
ıe top of the timbers (bowsprit E E) may be flush with the line
ck. The scraper frame to be raised and lowered by the hori-
rum K, worked by the hoisting engine as before illustrated,

The chains or falls being entirely under the deck, leaving the
ıcumbered, and the capstan J and bits L (plate No. 7) free to
ıs such contrivances are intended on ordinary snag-boats.

ontana was built for the Missouri river trade, and the C. J.
or the Ohio, Cumberland, or Tennessee. The application and
ıe scrapers on these boats show that it can be applied with
ood effect to the boats now used on those rivers, to remove the
ıd bars which obstruct their low-water navigation, and, in fact,
er western rivers as well as the upper Mississippi. The method
ting the scraper on the Montana and Caffrey is precisely the
lescribed in my report of November 26, 1866, (see H. Ex. Doc.
. 70.)

be well to repeat it here, viz:

ıcraper being applied to the bow of a suitable dredge-boat or
ıeans of a bowsprit, drag chains, hoisting and lowering warp,
r tackles adapted to its use, is conveyed to the head or margin
oal to be dredged. It is then lowered to the bed or bar, and
ls of the steamer are turned backward in a direction to drag
er across the shoal, the steamer moving stern foremost with
nt of the water, if there be any such current.

ng been dragged entirely over the shoal, the scraper is again
ut of the water and the steamer returns bow foremost to the
eginning. The operation is again resumed as before, and con-
l a channel of the required depth and width shall have been

tion of the scraper is two-fold; first, it cuts up and loosens the

tions were received which required me to keep the Caffrey at work till the 15th November, or until there was danger of the river being closed by ice.

The officers and crew of the Caffrey were as follows: One superintendent in charge, H. C. Long; one pilot, A. Russell; one mate, A. Caulchsure; one carpenter, J. Trower; one first engineer, T. C. Connelly; one second engineer, E. Rhodes; one steward, one cook, one second cook, one watchman, two cabin boys, two firemen, twelve deck hands—in all 26 men.

In conformity with instructions, the Caffrey left St. Paul November 1, running down to Gray Cloud, 18 miles, for the purpose of testing the engines and purchasing fuel. Everything in her working apparatus being found satisfactory, we commenced operations with the scraper at Frenchman's bar early next morning. My attention was called very particularly to this bar in your orders of 18th October. It was considered the worst on the upper river this season; being directly in view of the city, it was an eye-sore and cause of offense to the inhabitants and those having business or travel on the waters of the Mississippi.

I shall therefore describe more at length my operations at this locality. When we arrived at the foot of the bar the boat was landed and the yawl, with the mate and pilot, dispatched for the purpose of making careful soundings to ascertain its true condition. The crest of the bar was defined by several buoys. In the shoalest part of the channel, near the right-hand shore, a depth of 2½ feet with lead line, or 3 feet scant with sounding pole, was found, and this was the only available opening through the bar for all the steamboats plying between St. Paul and the ports below. Accordingly, I directed that the scraping should commence and be carried on in direction of the current and across the lowest point on the bar, following the most feasible steamboat channel. This plan of operation was pursued until the close of the day. For nearly two weeks previous to this date (November 2) no side-wheel steamers were seen at the St. Paul landing, principally owing to the difficulty in passing Frenchman's bar, and in part owing to bars between this place and Prescott, 30 miles below, commerce in this portion of the Mississippi being restricted to light-draught stern-wheel boats.

As evidence of our success at this bar, I will mention that after about four hours' work Mr. Saunders, the agent of the northern line steamers, passed down on the stern-wheel steamer Charlie Cheever, for the purpose of lightening the large side-wheel steamer Dubuque. Observing the Caffrey at work, and that we had already deepened the water very considerably, Mr. Saunders sent word to the Dubuque that she could cross the bar without further difficulty, which was effected in the course of the afternoon with two heavy barges in tow, the boat being enabled to proceed to St. Paul and discharge her large and valuable freight at the city levee or landing. We had then secured the depth of 3½ feet entirely across the bar. The letter of thanks from Mr. Saunders, addressed to you under date December 19, 1867, and of Captain T. J. Buford, superintendent of the northern line, fully corroborate these statements. Early Monday morning (November 4) work was resumed on Frenchman's bar and continued until noon. Ascertaining by careful soundings that we had procured a depth of four feet, it was deemed sufficient, and the Caffrey proceeded to points below. It is not necessary to give in detail each day's operations; suffice it to say that between the 1st and 15th of November not only Frenchman's, but all the bars between St. Paul and Prescott were examined and worked when it was found necessary. We may instance in particular the bars above and below Newport, at

ıds, and the bars above and below Nininger. In no case did without deepening the water to 3½ or 4 feet, besides cutting rojecting points of the reefs and straightening the channel. operations with the scrapers commenced, no boats that were nnel were found sticking on the bars, and up to the close of ı the largest side-wheel steamers, or at least all drawing from t water, could come with facility to the port of St. Paul.
:h not required to do it by your instructions of 18th and 19th :e made use of the Caffrey as a snag boat, pulling several very obstructions of this character from various bends in the river, he following table.

:ing date, locality, and number of snags taken from upper Mis. between Hastings and St. Paul, by the United States steamer C. :y.

Locality.	No.	Remarks, &c.
ıd above Gray Cloud.....	1	Cotton-wood, about 40 feet long, 14 inches diameter one foot from butt.
ɔt of Robinson chute, mid-lle of low-water channel.	1	Hackberry, about 20 feet long, 10 inches diameter one foot from butt.
ɔt of bar above Newport, ery much in the way.	1	About 35 feet long, 15 inches diameter one foot from stump; very large roots; about three hours getting this snag out of channel and on to bank.
ıd below Kaposia, directly n channel.	1	Very large elm, 60 feet long, two feet diameter at small end, three feet diameter 30 feet below, estimated four feet diameter near butt; got one end on bank; worked five hours on this snag.
posite Quarantine, directly n channel.	1	Log with small roots, easily removed.
's Eye bar, in channel.....	1	Log with small roots, easily removed.
's Eye bend, directly in hannel.	1	35 feet long, two feet diameter one foot from butt; very hard to get out.
's Eye bend, directly in hannel.	1	Stump 10 feet long, 34 inches diameter; very dangerous.
Total.....	8	

ıags were hauled entirely out of the channel, and, in every ıt one, up on to the bank, and cut up so that there was no dan-r getting again into the river and forming obstructions to . A number of overhanging and projecting trees were also :he bank. The Caffrey was not supplied with an outfit for nor was she intended for such a purpose. The snags taken out much in the way, and I wished also to show that the scraper ı to her bow did not unfit her for other services. In fact, it ly have been detached and replaced in one hour, as was suc-ried with the much heavier scraper on the Montana.
thus far spoken of the performances of the C. J. Caffrey Paul; no less remarkable and successful were those about ıbove the city, at Mendota bar, mouth of Minnesota river.
ɔdes, secretary of Northwestern Union Packet Company, you a letter in behalf of Captain Davidson himself, under ɔer 29, 1867, calling your attention to the bad condition of luded to, saying, "our Minnesota river boats are very much : this place," and requesting you to order me with the Caffrey : its improvement.

Accordingly, on the 11th November I proceeded to the mouth of the Minnesota for the purpose indicated. On making the usual preliminary examinations and soundings we found but two and two and a half feet water over the crest of the bar and some distance above; our first operation was to pull off a large barge loaded with wood, which was hard aground directly in the channel; we then made several attempts with the scraper, but were obliged to desist without accomplishing anything essential, by reason of prevailing high winds.

On the 12th we again steamed to the bar, and after four hours' work and 34 scrapes or drags over the bar, in the best line for the channel, we produced a uniform depth of three feet entirely across same.

For instance, barges loaded with 500 sacks of wheat found great difficulty in crossing the bar, almost always grounding, before the use of the scraper; afterwards, loaded with 900 to 1,000 sacks, they accomplished this object without the least difficulty. Thus the use of the scraper nearly doubled the capacity of this river at this point for all the uses and advantages of commerce. To prevent any misunderstanding, or the supposition that these beneficial results were due to any swell or rise in the river, I wish it to be particularly noted in this connection that the guage records, kept by your order in the most careful and systematic manner, showed a constant decline in the volume of the river during the entire period of the operations of the Caffrey.

The difficulty in operating at Mendota consisted in the fact of there being less water on the bar by six or eight inches than the draught of the Caffrey, the narrow and limited space for a boat of her size to maneuver in, and the very sluggish current, the latter being of little or no assistance in washing out the channel after the material forming the bars had been stirred up and cut up by the scraper, so that the success of the experiment depended entirely upon the two-fold action of the machine, as explained in a preceding paragraph of this report.

The Mendota bar was composed of mud, sand, and saw-dust, with a large mixture of brickbats, thrown over by barges loaded with the latter commodity in lightening. On the 13th November, the Caffrey run down to Gray Cloud and returned to St. Paul with two barges in tow loaded with 150 cords of wood, showing the practicability of side-wheel steamers reaching St. Paul at this season of the year and low stage of water, by means of the channels she had opened through all the worst bars between that place and Prescott.

Having received letters from Captain Davidson and William Rhodes, president and secretary Northwestern Union Packet Company, under date November 15th, to the effect that the work already done by the scrapers was sufficient to enable their boats "to get along without difficulty," "and no more was required," under your instruction I left St. Paul with the Caffrey for Dubuque, Iowa, November 16, arriving there the evening of the 18th.

Business on the river was there nearly finished for the season; the United States mail service ceasing on the 15th, and there being indications of a speedy and entire suspension of navigation by ice, it, was deemed advisable to pay off and discharge the crews of the Montana and Caffrey, which was accordingly done, and the boats lay up for the winter in a safe and convenient harbor near the city.

In regard to operations the next ensuing low-water season, I beg leave respectfully to make the following suggestions:

1. The steamer Caffrey should be hauled out on the ways as soon as practicable, her bottom overhauled and recalked, defective timbers removed, and replaced. This is very necessary.

exas should be taken off, pilot-house lowered, and her cabin one-third its present size, or only sufficient for the accommo- officers and crew. These alterations will lighten her consider- ake her much more manageable in a high wind, besides reduc- ense of running and keeping her in order. The Caffrey may pected, with proper use, to last several years as an efficient d dredging boat, and can be used for snagging also.

erations and repairs may be estimated as follows:

t on marine way, recalking, &c	$2,500
ull, cutting down and reducing cabin	2,000
er" or hoisting engine, and fixtures	1,000
including derricks, windlasses, and extra rigging for purposes	1,500
ations contingent to above, say	500
ling, &c	500
	8,000

Wisconsin river, where a snag boat is much needed, I am of t the best and most efficient boat will be one built on the Gopher or Dragon, formerly used on the Ohio, Arkansas, and rivers, drawings of which are on file at this office. A scraper with such a boat. She will probably cost, complete, $30,000.

efficient boat of another description may be built for less ollows:

or scows of very strong construction, 75 feet by 16 feet each, gether at bow and stern, with an open space between about and 40 feet long.

l about three and a half feet deep, whole to draw 16 or 18 h machinery, tools, tackle, &c., on board. On this I pro- t transom ways with traveling crane or other hoisting appa- at snags may be lifted through the open space between the et by 40 feet,) or on either side.

e furnished with double-action piston, or nigger engines, and otive boilers, or other suitable lifting gearing for the purpose ig snags, stumps, sawyers, rocks, &c.

osed to tow or float this boat down the river to any required hich purpose the scraping steamer Montana or Caffrey may hout interfering with their legitimate business.

f this description may be estimated to cost as follows:

r flats (very strong) at $1,500 each	$3,000
pars, framing for traveling crane, &c	1,500
lers, tools, tackles, and other machinery	3,000
lency and contingencies, say	500
	8,000

lly submitted,

HENRY C. LONG,
United States Civil Engineer.

Bvt. Maj. Gen. G. K. WARREN,
Corps of Engineers, U. S. Army.

Report of H. C. Long, United States civil engineer, of the alterations and repairs of the steamers Montana and C. J. Caffrey, to adapt them to snagging, and of their operations in 1868, *with one plate.*

UPPER MISSISSIPPI RIVER,
U. S. Steamer Montana, August 31, 1868.

GENERAL: Under your instructions I made a report, dated December 31, 1867, giving a history of the construction and introduction of Colonel Long's scraper on the improvement of the upper Mississippi river, its adaptation to the ordinary side-wheel steamers used in the navigation of this river, and the operations in snagging and dredging of the steamers Montana and C. J. Caffrey, to which this apparatus is attached.

This report was illustrated with detached drawings of the scraper, and narrated all of interest in the premises, as far as I had any special connection with the business, and extends to the period when it became necessary to lay up the boats in winter quarters, November 20, 1867.

I shall now endeavor to give you as briefly as possible, the subsequent history of the boats, and their operations on the river improvement to the present date.

Acting under your instructions of February 1, 1868, I proceeded to Alton, Illinois, and St. Louis, Missouri, and made an examination of the harbor at the former place, and mouth of the Missouri. The results were given you in my report of March 24, 1868, referred to the Committee on Commerce and ordered to be printed, April 21, 1868. (See 40th Congress, second session, Ex. Doc. 257.)

On the 22d of April I arrived at Dubuque, Iowa, where the steamers Montana and Caffrey had been placed in winter quarters, and at once commenced the preparation of a report and plans of repairs and improvement of the boats, suggested by our last year's experience, and deemed conducive to their more efficient operations during the present low-water season.

These plans were submitted to you on the 29th of April and 6th of May, respectively, and your approval to same was received on the 16th and 17th of the month last mentioned.

The roof of the Montana was found to be in a very leaky condition; a thorough removal and repair was considered necessary. This was satisfactorily accomplished at Dubuque, occasioning a further delay at that place of some eight or ten days.

It was decided, as most economical and convenient, to go for further repairs and alterations to the dock-yard of the Northwestern Union Packet Company, near La Crosse, Wisconsin.

Accordingly steam was raised on the Montana Tuesday, June 2, but an accident occurring to the piston-head of the larboard engine, we were detained for necessary repairs until the 6th. On the morning of that day we left Dubuque, the Montana having in tow the Caffrey and the Wisconsin surveying quarter-boat, and arrived at La Crosse about 3 p. m. of the day following. The Caffrey was placed on the marine ways at the dock-yard on the 13th June, and launched on the 26th. Her bottom was thoroughly overhauled and recalked, rotten and defective planks removed and new ones inserted in their places. Her bows forward of the capstan were removed and a new stem-piece introduced from the water-line to the main deck. The repairs also included new water-wheel beams and braces, new timbers in her hull, framing, &c., in fine, everything was done that appeared necessary to insure trength and efficiency in the very arduous service for which she was

ended. The cost of these repairs complete was about $3,800, includ-
material and labor expended in alteration and improvement to her
gging and scraping apparatus, which consisted mainly in the removal
he old hoisting engine belonging to the boat and replacing it with
more powerful one used last season on the Montana.

he Caffrey left the dock-yard June 30, and was towed by the Montana
convenient position one mile above La Crosse, where her officers
crew were shipped and her outfit completed.

n the 12th July the Caffrey left La Crosse for operations on the
s and sand-bars between that place and St. Paul, and has continued
larly at work ever since, without the loss of a day by accident,
mplete construction of machinery, or from any other cause.

your instructions of February 1, 1868, Captain N. F. Webb, well
n and highly respected in the west for his experience, skill, and
judgment in all matters pertaining to the navigation of western
s, was directed to act as my assistant.

ptain A. R. Russell was appointed master of the Caffrey, with your
oval, on the 1st of July, and from that date took special charge
r.

these gentlemen and Captain D. S. Stombs, of St. Paul, master
anic and machinist, I am indebted for valuable counsel and co-
ation.

r further information respecting the detailed operations of the
ey I respectfully refer you to my instructions to Captains Russell
Webb, and their reports. (See Appendix A, B, C, D, herewith.)

e Montana has not been subjected to alteration so materially
ging her general appearance as the Caffrey, although about the
amount of work has been expended on her, consisting mainly of
ng her guards, boiler deck, and hurricane deck forward of the fur-
, in order to give more room for working her snagging apparatus.
hull above the water-line has been recalked and painted three
, and every part of the boat put in good substantial repair and
ing order.

r snagging apparatus has been made as complete as could be devised
boat not specially built for the purpose, which has also to combine
wo offices of dredging and snagging, and consists of two heavy
s 18 feet high with 18 feet beams, worked by a double cylinder
e, 14 inches stroke, 6 inches diameter. These engines also raise
ower the scraper, it requiring but one man to attend them in their
le duties. Alterations have been made in the position of her
er with reference to the main deck, which enable her to scrape two
nore in depth below the surface of the water, making nine feet in
nd at the same time giving more deck room.

e alterations and repairs just alluded to occupied much time, owing
e necessity of getting the Caffrey completed first, and at work with
east possible delay, and the great difficulty of procuring skilled
anics in a new country, where the demand exceeds the supply.

one time in July and August, there being a great call for laborers
e harvest field, it was not unusual to pay $3 50 to $4 50 with board
y laborers.

e Montana commenced work on the snags and bars August 26th,
rill be kept thus engaged for the balance of the season.

r a detailed report of her operations to date, see Appendix E, and
ostcript to Captain Webb's report, Appendix D.

e expenses attendant on the repairs, alterations, scraping and
ging operation of the Caffrey and Montana, from April 18 to
st 31, had amounted to about $20,000.

They may be classified as follows, in order to give a general idea of their extent and cost:

C. J. CAFFREY.

Docking expenses	$3,000 00
Snagging apparatus, (incomplete)	300 00
Alterations to hull, cabin, &c.; removing texas and cutting decks	500 00
Stones and outfit	1,000 00
Running expenses while scraping and snagging, including fuel for steam, pay, and subsistence for officers and crew, &c, seven weeks, at $7 50 per week	5,250 00
Total	10,050 00

MONTANA.

New roof on hurricane deck	$1,000 00
Snagging apparatus complete, cordage, tools, tackle, blocks, &c., &c	3,000 00
Alteration to scraper frame, &c	400 00
Cutting off guards, main deck, hurricane roof, calking, painting, &c.	850 00
Stones and outfit	1,200 00
Use of a barge or lifter, 50 days, at $5	250 00
Pay-roll of mechanics and laborers, scraping, and snagging expenses, pay of officers and crew and subsistence, &c	3,250 00
Total	9,950 00
Or about $10,000 each, amounting to	20,000 00

Thus far our operations on the river have proved successful. The Caffrey has in every instance succeeded in increasing the depth of water on the bars from eight to eighteen inches, or where navigation was obstructed by a depth of 2½ to 3 feet only on the crest of the bars, or along a succession of reefs, it was deepened to 3½ or 4 feet large, so that first-class side-wheel steamers have been able to run regularly to St. Paul, since she commenced work on the 21st of July last. Before the repairs to the Caffrey were complete, or about the 20th of June, steamboats began to find difficulty in crossing the bars above La Crosse, and there was a general clamor for the scraper or government boats, as they were called by the public papers, giving testimony of a suitable appreciation of their services.

The water reached its lowest stage about the 15th of July, 16th and 30th August, respectively; at the two first dates, it may be considered as having been at a two and a half foot stage, and at the latter at a two foot stage. The river has raised and lowered at different times between the periods mentioned some five or six inches as observed by the pier marks at St. Paul.

Working drawings have been made and complete sketches of the Caffrey and Montana showing all the details of their snagging and scraping machinery and the various alterations of their hulls and other works, but time does not permit their being constructed on a reduced

suitable for insertion in this report, and only a perspective view Montana as she appears complete is here given.
pectfully submitted.

H. C. LONG,
United States Civil Engineer.

r and Bvt. Maj. Gen. G. K. WARREN,
Corps of Engineers U. S. A., Supt. Survey and Inspt. Northwestern Rivers, &c., &c.

e in the original is a drawing of the steamer Montana as she s complete.]

APPENDIX A.

Instructions to Captain Russell.

LA CROSSE, *Wisconsin, July* 9, 1868.

As you were verbally appointed to take charge of the United steamer C. J. Caffrey on the 1st instant, you will now proceed dispatch to use her for the purpose for which she was originally d and has been lately refitted at the dock-yards of the Northwest- ion Packet Company at this place, that is, scraping or dredging s which obstruct navigation on the upper Mississippi river. You the present confine your attention to the bars between Prescott, sin, and St. Paul, Minnesota, operating first on those which seem ire it most, or those bars having three feet or less on their crest, ng, straightening, and deepening the most practicable low-water l across the same, according to the best of your judgment, after- giving attention to other bars in succession, so as to have an unin- ed channel between St. Paul and Prescott.

ain N. F. Webb will accompany you for a few days. His long nce in western river navigation and acknowledged skill in mat- t pertain to the subject, will render your attention to his advice greatest benefit. You are accordingly directed to advise with n Webb fully and freely, and avail yourself of the benefit of his and experience in the discharge of the duties intrusted to you.

e also furnished with a copy of the rules and regulations for the government of the United States snag and scraping steamers, ou are required to observe.

not to be expected that I can give you directions anticipating and g all the details of the duties connected with the work under pervision, but it is expected that economy, order, and efficiency vern all your operations, resulting in the best interests of the States service, and personally redounding to your own credit utation.

Very respectfully,

HENRY C. LONG,
U. S. Civil Engineer, in charge U. S. Snag and Dredge Boats, Upper Mississippi River.

ain A. R. RUSSELL.

APPENDIX B.

Instructions to Captain Webb.

LA CROSSE, *Wisconsin, July* 11, 1868.

r SIR: You are hereby directed to proceed up river with the C. ey, A. R. Russell, master, and to take a general supervision of

the operations intrusted to Captain Russell, aiding him with your counsel and advice.

It is suggested that you go at once as high up as St. Paul, and thence work in succession on all the bars as far down as to include Rolling Stone, if you think it is necessary to do so in order to keep open river communication.

I have, in my instructions to Captain Russell, indicated that portion of the river between Prescott and St. Paul as being his special district for scraping at the same. I wish the Caffrey to work as far down the river as, in your judgment, may be required, until this boat Montana is ready for service.

After fully inspecting the condition of the river and inaugurating the operations of Captain A. R. Russell, you will report to me in person at this place.

Very repectfully, your obedient servant,

HENRY LONG,
U. S. Civil Engineer, in charge of Dredge and Snag Boats, Upper Mississippi River.

Captain N. F. WEBB,
Upper Mississippi River Improvement, &c., &c.

APPENDIX C.

Captain A. R. Russell's report, consisting of extracts from log-book, detailing operations of United States dredge and snag boat C. S. Caffrey.

Redwing, July 12, 1868.—Left La Crosse at 5 o'clock a. m., and proceeded up river. Found four feet water on Black river crossing and four feet scant on Trempeleau bar. Ran the little slough or Horse-shoe bend at Rolling Stone for the purpose of making an examination of the same. Found three feet on shoalest place. Took soundings over Beef slough, the shoalest crossing being the one opposite or a little below the head of old Beef slough, crossing from left bank to shoulder of island above the little tow-head soundings, three and a half feet on one side and four feet scant on the other, the balance of the crossing ranging from four to five feet.

Arrived at Redwing at 10 o'clock p. m. Lay over until morning. Took on 13 cords of wood during the day, running a distance of 120 miles.

St. Paul, July 13, 1868.—Left Redwing at 4½ a. m. Proceeded up river; took soundings on Prescott bar, crossing over to Point Douglas, above head of Prescott island. Found four feet scant. Found four feet scant on Nininger bar, (upper crossing,) three and a half at head of Belonger's island, and three feet scant on the lower end of Gray Cloud bar, crossing out from the little island to wood-yard on left bank. Sounded thoroughly and found there was more water to run the bend to the Old Lone-tree crossing, then middling square out toward the point and up the middle of the river, until you struck the channel, and running the channel the other way. Found three and one-half feet at Red rock, three feet at Pig's Eye, and four feet at Frenchman's bar. Arrived at St. Paul at 2 o'clock p. m. Stored surplus lumber, rigging, &c., in the government warehouse, and left in the evening for Gray Cloud bar, it having the least water of any on the river. Took on 27 cords of wood and ran 78 miles.

July 14.—Commenced dredging on upper bar at Gray Cloud. Found it of a very hard composition; worked until noon, and not being able to

ffect much, left that and went to work on lower crossing from the island o the point, a wood-yard on left bank.

From three feet scant, dredged the channel to three and a half feet, nd left for Pig's Eye, the next worst place, at 4 p. m. Found three feet, orked until sundown, and increased it to three and a half. Lay over ight at St. Paul. Took on 10 cords of wood during the day and ran 22 niles.

July 15.—Proceeded down river. Found Pig's eye bar in need of more caping, worked on it about one hour, leaving three and half feet. Found he other bars with three and a half feet and upwards, except Grey Cloud, which had filled in somewhat during the night. Left three and half and continued down the river. Found three and a half and over ll the way to Prescott. After consulting with Captain Webb, concluded o go to Beef slough. River fell at St. Paul one inch in 36 hours. Lay ver at Wabashaw. Took on 10 cords of wood and ran 94 miles.

July 16.—Left Wabashaw at 5 a. m. Found four feet scant on two ars, the balance of the crossing having over four feet. Made search for pile of stones said to have been thrown overboard to lighten a barge hat ran aground; after some time found them about two rods above he first crossing, below the head of Old Beef slough, and near the cen- er of the slough. Put a large buoy on them. We then marked all the rossings by nailing up painted boards in a conspicuous place to be seen either going up or down. Dredged the shoalest bar to the depth of four feet large. At 3 o'clock left for Rolling Stone bar. Took on 14 cords of wood; ran 35 miles.

July 17.—After an examination of the three different channels at Roll- ing Stone and taking soundings of same, I found as good water in Horse- shoe bend or Little slough as in any other part, besides being most con- venient to navigate. The shoalest place, three feet scant, was at the head of Horseshoe island. The middle crossing in the main river was crooked with cross current, and a very unnatural water course, although most of the boats ran that way. Shoalest place three feet large. The third channel on the left or Wisconsin shore started in below the Dark Slough island, and ran up that shore with three feet scant in shoalest part, the reef running parallel with the shore at the crossing. Consulted with Captain Webb and concluded to dredge out Horseshoe bend as the most practicable route. Commenced work after breakfast. Cut two trees, one of which measured 22 inches at the stump and 35 feet in length, reaching out over the channel at an angle of about forty-five degrees, and taking up the best water. Had it hauled out on the bank. Proceeded to dredge bar. Found a log two feet at the root and about 40 long buried in the sand in the channel, and had it hauled out upon the bank. In- creased depth of water four to four and a half feet. Worked until 5 o'clock, and having done all that was necessary for the present at this place, ran to Minneiska, 18 miles. Took on 12 cords of wood.

July 18.—Left Minneiska at 4 o'clock a. m. Found Beef slough in good shape with four to five feet at all the crossings—the stone-pile crossing the shoalest, having four feet on one side and four feet scant on the other. Made some improvements on the marks at the lower crossing, and cut a leaning tree on the bank. Stopped above the Clara Hinde wreck and cut two trees leaning out over the channel; also hauled out a snag at this point, measuring 45 feet in length and 23 inches at the stump. Left at 9½ o'clock. Found a big stump lying loose on the bar about a mile below Wabashaw opposite the upper tow-head, and immediately in the channel, with a large root attached to it. Hauled it out on the Wabashaw shore. It measured 10 feet in length and 26 inches at top

end. Went on up river at 10½ o'clock. Met a slight rise of perhaps six inches. Found four feet large on Douglass bar; five feet at Nininger, lower bar, with four feet large at upper crossing; four feet at the head of Belonger's island; four feet at Grey Cloud, lower crossing; channel about as we left it; four feet scant at Pig's Eye on one side and four feet on the other. Arrived at St. Paul at 11 o'clock p. m.

Sunday morning, July 19.—The river has risen about six inches since we left on Wednesday morning. It is now at a stand.

July 20.—Engineer and carpenter worked nearly all day yesterday repairing deck under ash pan, which was giving way and letting through the stands of ash pan. Left St. Paul at 7 a. m. Found four feet scant on Pig's Eye, and three and a half on Gray Cloud. Took on four cords of wood and worked here till about 12, and then went on down river. Met the Montana at Hastings. After leaving her went down to the snag below Hastings and worked about an hour trying to get a hitch on it, but found it so much buried in the sand that it was useless to try to do anything without proper rigging. Went on to Prescott and made search for a snag or stump that two or three boats have hit. It is said to be nearly opposite the head of Prescott island and near the middle of the river. We could not find it. Continued down the river, stopping for the night at Waconta. Took on 10 cords of wood here, 14 during the day, and run 65 miles.

Tuesday, July 21.—Left Waconta at 4 o'clock, arriving at Beef slough at 7½ a. m. Found an old snag anchored in the head of the Little slough and hauled it out on the bank. It was 25 feet long, 16 inches at the stump, and eight at the top, with a heavy root. Undertook to scrape the stone-pile down into deep water, but found that they could not be moved with the scraper without scraping them towards the channel we had made. I therefore abandoned the idea of doing anything with them for the present. Found four feet scant on the bar here, and worked on it till I made four feet large. Also worked on the next one below, leaving four feet large on it. Had the red crosses put on the sign boards at the crossings. Cut some leaning trees and hauled them out on the bank. Left at 3 o'clock and arrived at Rolling Stone at 5. Put in remainder of day cutting trees and stumps at head of Rolling Stone island. Run 65 miles. Took on 12 cords of wood.

Tuesday, July 22.—Heavy fog till 8 o'clock this morning, so that we could do no scraping. Cut some impending trees, made and put up additional marks for the crossing in the main river. Put up a good one on each shore to indicate the starting point going up or down. Also drove stakes and put up four on the lower edge of upper reef, on the prominent points of same. Run the boat through the slough and found least depth four feet scant. Scraped principally on lower side in order to widen the channel; also made it from four to four and a half feet deep. Left for Trempeleau bar at 3 p. m., where it was reported that boats were rubbing very hard. Found four feet scant. The Keokuk came over a few minutes after we got there, crossing where there was three and a half feet, and rubbing because she did not run in the best water. Commenced scraping at 5½ and worked till 7½ p. m. Run 24 miles.

Wednesday, July 23.—Commenced work at 6 a. m. By sounding with the yawl while the boat was scraping, I found a channel of four feet large in the shoalest place, which the boats have not yet discovered. It stands out from the island under the reef that we have been dredging, runs across to the Wisconsin shore towards the lower high point of bluff back of town, up that shore to the head of timber, and then stands out until striking the channel usually run. At 10 o'clock the Keokuk went over

the bar without much of an effort. Worked until 4 p. m., making a good wide channel of from four to four and a half feet. Put up a mark on the island to run by, running from that to highest part of bluff back of town. Proceeded up river. Stopped at Winona for stores. Run to Wild's wood-yard. Took in 10 cords of wood. Run 20 miles.

Friday, July 24.—Left Wild's landing at 4½ a. m. Found four feet in main channel at Rolling Stone. Stopped at Beef slough and worked from 9 o'clock to 12. Packing blew out of larboard cylinder, and had to land to fix it. Started up river at one. Found a snag in the channel at the head of Waconta island, a good sized tree, with a heavy root and forked top. It was about 35 feet long, each of the prongs measuring eight inches in diameter at the top. Had it hauled down behind the island, out of the way of navigation. Took out another about two miles further up, which was 38 feet long and 20 inches at the stump. Stopped at Diamond bluff for the night. Took on 20 cords of wood. Run 93 miles.

Saturday, July 25.—Started at 5 a. m. Took out a snag about three miles above Diamond bluff, 50 feet long and 16 inches at the stump, with a heavy root. Hauled out a tree opposite the first point above Hastings, on the right shore of the river, an old settler, that the boats have run around for years. The top was buried in the sand, the butt rising and falling with the water. Tried to get out another above this, but after breaking off all the limbs, could not make fast to the butt, and had to abandon it. Took out a small snag from the channel at the upper bar at Nininger, 20 feet long, and 12 inches at the stump, with root attached. Found four feet at Nininger, four feet at Grey Cloud, and the same at Pig's Eye. Scraped on the latter until 5 o'clock to straighten channel. Arrived at St. Paul at 6. Run 40 miles.

Monday, July 27.—Spent the forenoon repairing capstan and rigging. Left at 2 p. m. Four feet on Pig's Eye, with channel in good shape. Reached Grey Cloud at 4½ p. m. Found 3½ feet large, worked it out to four feet, and left at 7 o'clock, going down river. Found 3½ feet large on Nininger, and concluded it would do until I came back from Trempeleau. Ran to Diamond Bluff, 42 miles.

Tuesday, July 28.—Took on 11 cords of wood and started out at 6½ a. m. Considerable fog on the river, and had to lie to for a short time after running half an hour. Pulled out a heavy snag in the channel at the foot of Diamond island, 30 feet long and about 26 inches at the stump, with heavy root. Passed Redwing about 9. Continued down without detention, until we came to Beef slough. Found four feet scant on the stone-pile crossing; made four feet and left at 1 p. m. Found over four feet at Rolling Stone, and the channel in good order. Took on four cords of wood at Wild's landing. Stopped a few minutes at Winona, and continued on to La Moile, where we stopped for the night. Took on 12¾ cords of wood and ran 105 miles.

Wednesday, July 29.—Started at 6.30 a. m. and run down to Trempeleau bar. Found four feet on the main crossing where we dredged last week, with channel in good shape. Ran the lower crossing previously spoken of, and found four feet nearly, the same as before; also took soundings on the reef at the upper side of main channel, where the Keokuk was running before we worked on the bar. Found 3½ feet as before.

In compliance with Captain Webb's orders turned my course up river at 7 a. m., as there was no need of doing any work here. Passed Rolling Stone at 10.40. Found four feet large. Beef slough, 1.45. Found four feet scant on the stone-pile crossing, and four feet large on the cross-

ing below. Continued up river. Took a wood-flat in tow at Redwing, with 21 cords wood. Stopped for the night at 10 p. m., three miles above Hastings. Ran 130 miles.

Thursday, July 30.—Rained very hard during the night. River rose one inch in eight hours. Started out at 6.15 a. m. Found four feet on Nininger bar. Scraped here awhile for the purpose of keeping the channel in its proper place, there being symptoms of its changing to where it was in the fall of 1867, and the present channel being much the straighter of the two. Left four feet large and went on up to Grey Cloud. Found four feet scant and increased it to four feet. Hauled out a cottonwood tree about 35 feet long and 40 inches at the stump, that lay alongside the channel. Took it down about eight rods, and out of the way, in doing which we parted one of our lines in two places. Left at 2 o'clock. Found four feet at Pig's Eye. Touched at St. Paul at 5 p. m. to leave Captains Webb and McCuen, and then went back to Pig's Eye and worked till 6.30 p. m. Lay there over night. Ran 30 miles.

Friday, July 31.—River at a stand during the night. Scraped a little while on Pig's Eye and left at 7 a. m. Found 4½ feet on Robinson bar, right of island. Run the upper crossing at Grey Cloud bar, and found four feet scant. Commenced work on lower crossing at 8.45. No perceptible change since yesterday. Worked till 11 o'clock. Pulled out a snag next to island, 40 feet long, 22 inches at stump. Started at 12.30 and ran eight miles below Prescott. Took on 27 cords of wood and returned to Nininger at six, where we lay for the night. Ran 56 miles.

Saturday, August 1.—Started out at 6.20 a. m. Commenced scraping on Grey Cloud at 6.50. Found four feet scant. Worked till 11.45, leaving over four feet. Arrived at St. Paul at 3 p. m. Ran 25 miles.

Monday, August 3.—Left St. Paul at 6.30 a. m. Found 3½ feet on Pig's Eye, and commenced scraping there at 7. Made an examination of the water to the left of island. Found a great deal of water going that way, and a very good channel with three reefs to cross, the first, four feet scant; the second, 3½ large; and the third, four feet. Put up marks on the shore, and scraped on old channel until 11.20. Went on down. Found 3½ feet at Grey Cloud, upper crossing, and four at lower, with channel in good shape. Put no marks at the upper crossing, there being indications of a change in favor of the lower, which, if anything, had more water than we left there on Saturday, the 1st instant. Dredged this latter for a short time, and put marks on the island and the opposite point. Started for below at 2 p. m. Found 3½ feet at Nininger. Took on 12 cords of wood at Diamond Bluff, and lay for the night at Wacouta. Ran 65 miles.

Tuesday, August 4.—Left head of lake at 6 a. m., heading down river; considerable fog. Passed Beef slough at 9.45. Found four feet scant. Arrived at Rolling Stone at 12 m. Put up marks of the largest size on both sides of the river and cleared away the timber so that they can be seen up and down the river. Scraped lower side of the channel to bring it more with the current. Left four feet large with good width and turned up river at 3.30. Took in 12 cords of wood at Minneiska; reached Beef slough at 7.30 and lay over for the night. Ran 95 miles.

Wednesday, August 5.—Started out at 6.15. Found four feet scant on tow-head crossing; worked it out to four feet. Found and left the same on stone-pile crossing, also pulled out a stump anchored here and put up large marks on both sides of river. Left at 11 a. m., going up. Pulled out a snag, 30 feet long and 25 inches at the stump, a little above Shingle landing. Went on up at 4.30. Worked in Vermilion bend on

ome snags and trees that were much in the way. Hauled out two trees ull length, one about 28 inches at the stump, the other 24; also cut two rees leaning over the river, one 20 inches at the stump, the other 18, nd hitched to a solid old snag that we had hard work to start; worked on it ntil dark, and finding our rigging not strong enough to raise it we were bliged to leave it. Lay there until morning. Ran 50 miles.

Thursday, August 6.—Started at 5.40 a. m., taking a wood barge in ow at Diamond Bluff. Found four feet on Prescott bar, three feet at ead of island below Douglass, and three and a half feet at the upper ar; scraped at the latter until we had four feet scant, and left at 11.20. ound three and a half feet at head of Belonger's island, and three and half feet scant on lower Grey Cloud. Dredged here till four p. m., and ft four feet. Found three and a half feet at Red rock. Lay up at the uarantine buildings at 7.15 p. m. for the night. Ran 50 miles. Took 20 cords of wood.

Friday, August 7.—Started out at 5.30 a. m. Found the Key City ground on Pig's Eye, where she had lain all night. Made fast a line nd pulled on her until we found our capstan about to give way; though till strong enough to work the scraper. We then pulled on her by acking down on a line, but had none that would stand the strain. arted two of ours and one of theirs. The Muscatine came up at 11.30, ried to get over bar and failed; she then backed down and tried the her side of the island, but did not succeed there. The Ida Fulton me up at 12.30, with barge in tow, and went by without difficulty; uscatine then came back, left her barge and went over with little ouble. I then went to work on the Key City again. She got off at .30 p. m. Being short of wood, ran down to Robinson's, took on 15 rds and returned to Pig's Eye, where we lay for the night. Ran 20 iles.

Saturday, August 8.—Started out at 6 a. m. Northern Belle came up the night and got over at 5.30 a. m. Found the bar in very bad shape d full of lumps, caused by the boats getting aground yesterday, with t three feet of water on them. Labored under great difficulty on count of a heavy wind blowing down river. Got aground at 8 o'clock, t after up-ending two or three times, got off without having to spar y. Assisted the Northern Bell over the bar at 11.30 on her way down. detained us but a few minutes. Milwaukee passed up at 3.30 p. m. ithout stopping. Left for St. Paul at 3.40 and arrived at 4.15, run- g only four miles.

Monday, August 10.—Employed Sunday in making repairs, which were t completed till 7 a. m. to-day. Left St. Paul at 7.30 a. m. Ran wn to Pig's Eye and found but three and a half feet water. Worked o hours and left four feet. The bar at foot of the island had four t. Robinson's bar the same. Lower Grey Cloud but three and a half t, scraped one hour and made four feet. Found three and a half feet nt on bar above Nininger, left it with four feet at 4 p. m. Found four t on the bar below Nininger, and four feet scant on Point Douglass r. Ran down to Diamond Bluff, and lay over night. Ran 42 miles, k 19½ cords wood.

Tuesday, August 11.—Started down river at 5.15, reaching Beef ugh about noon. Examined the bars and found four feet scant on . 1, or stone pile crossing, three and a half feet on No. 2, or tow-head ssing, and good four feet on No. 3, or lower crossing. Worked on s. 1 and 2 until we made four feet large on the former, and four feet nt on the latter. Headed up stream at 5.15 p. m. Tied up at 8.45 head of the lake for the night. Ran 107 miles.

Wednesday, August 12.—Under way at 5.20 a. m., made Prescott at 11.20, sounded chute to right of Prescott island, finding nothing less than four and a half feet scant. Found five feet on the bar below Nininger, and but one cast less than four feet on the next above. Reached lower Grey Cloud at 1 p. m. Found but three and a half feet on the bar. Worked it down to four feet large in less than an hour.

Arrived at Pig's Eye at 4.05 p. m., Captain Webb leaving us here for St. Paul. Found four feet scant on bar. Started down river again, making a few scrapes at Nininger (upper bar.) Tied up at Nininger. Run 84 miles. Took in 21 cords of wood.

Thursday, August 13.—Started down at 5.45 a. m. Point Douglass bar showed four feet. Entered lake at 9.35; reached Beef slough bar at 12.40. Found No. 1 four feet. Scraped it down to four and a half and four feet large. Found but three and a half feet on the upper side of channel over bar No. 2. Scraped here till night, and then tied up with less than four feet on lower reef. Ran 75 miles. Have taken five cords of wood.

Friday, August 14.—Began work on crossing No. 2 at 5.45 a. m; concluded to scrape lower down on the lower reef. Had good success in this, and at 9 a. m. had four feet of water there. Ran down to Alma for wood. Came back and examined lower crossing, finding good four feet. Scraped again on No. 2, which we left in better shape than it has been before, straight and wide. Sounded No. 1 and found four and a half feet. Started up river at 8.30 and tied up. Ran 52 miles. Taken 21 cords of wood.

Saturday, August 15.—Left Redwing at 5.20 a. m. Savanna came up and reported Trempelean bar getting troublesome. Found four feet on Point Douglass bar, five feet at lower Nininger, and four feet at upper. Found four feet scant on lower Grey Cloud and scraped it to four feet large. Arrived at Pig's Eye at 4.15 p. m. No change in gauge reading here since Wednesday. Cut a large elm and pulled it back from the river, which would have fallen across the channel soon. Sounded bar and found four feet with a few casts of four feet scant. Tied up at St. Paul at 5.35. Have left a good channel for the boats from Beef slough to St. Paul. I anticipate trouble soon at the lower crossing at Beef slough, as the sand from above is washing down there. Have run 420 miles this week and taken on 87 cords of wood.

Sunday, August 16.—Mr. Stombs put a new spindle in our capstan today. He began as soon as we landed last night, and did not finish until this evening.

Monday, August 17.—Left St. Paul at 7. a. m.; found four feet water on Frenchman's bar, and three and a half feet on Pig's Eye. Scraped on the latter two hours and made four feet. Arrived at lower Grey Cloud at 11.30 a. m. Found but three and a half feet here. Worked till 12.05 and had four feet. Sounded bar above Nininger and found three and half feet. Scraped it down to four feet in one hour and ten minutes. Bar below Nininger had five feet, and Point Douglass bar four feet with few casts of four feet scant. Broke two wheel-arms above Diamond bluff in passing a raft. Wooded at Diamond bluff, and tied up at Waconta. Run 60 miles. Took 12½ cords wood.

Tuesday, August 18.—Left Waconta at 5.15 a. m.; were two hours and a quarter in passing the lake. Four gentlemen—Hon. Frank Daggett, of the Wabashaw Herald; Mr. Charles Hamilton, agent Northwest Union Packet Company; W. R. Steele, of the Wilmington (Illinois) Independent, and Mr. O. E. Clark, Chicago and Alton railroad—came aboard here and accompanied us to Beef slough to witness the operations of

ne scraper. We deepened the channel at the upper crossing in 35 minutes to four and four and a half feet, beginning with three and a half eet large. They all expressed themselves highly pleased with the orking of the scraper. The other crossings here were good. Found our feet water on all the bars down to Trempelean, where we arrived at .15 p. m. Found the bar at the place in good shape, but boats have ad trouble by not keeping our channel. Made a few scrapes, improved ne guide-boards and ran up to La Moile for wood, and tied up there. ook 13 cords of wood. Ran 90 miles.

Wednesday, August 19.—Found Trempelean bar in bad shape this orning. The Flora got aground with two barges in the night, and ade lumps in the channel. Soundings from three and a half to four eet scant. Worked about two hours and made four feet, with some asts on the lumps of four feet scant; raining. Started down at 8.05 . m.; Black river crossing had five feet; landed at La Crosse at 11.20; ent on down to landing, took boxes, &c., aboard, and the quarter-boat n tow, and started up river at 4.10 p. m. Landed and tied up at Badax ood-yard. Took 18 cords wood. Ran 100 miles.

Thursday, August 20.—Left Badax at 5.15 a. m.; passed Brownsville, .45; La Crosse, 9.35; arrived at Trempelean bar at 1.15 p. m.; found it bout as we left it yesterday, began to scrape immediately, and worked ll we had good four feet in all places, leaving at 5.20 p. m. The Key ity came down while we were there, with two barges, each, Captain Webb said, drawing more than three and a half feet. She kept our hannel and had no trouble. Lay up at Winona without wooding, aving run 68 miles.

Friday, August 21.—Started from Winona at 4.30 a. m. Tied up for ght at Diamond bluff at 8 p. m.; found good water all the way up, ur feet at all the Beef Slough crossings, with but four feet at West owton bar; this and Alma bar will make trouble, if the water falls uch. Had one cast on the latter of four feet scant; the remainder four et, and four feet large. Have taken 31 cords of wood and run 115 iles.

Saturday, August 22.—Left Diamond bluff at 5 a. m.; reached Pres tt at 7; Point Douglass bar sounded four feet, one cast four feet scant; r above Nininger four feet, and Belonger's bar the same. Arrived at wer Grey Cloud bar at 8.40; found three and a half and four feet scant. orked two and a half hours there and left four feet. Reached Pig's ye bar at 2.20 p. m.; this bar had three and a half and four feet scant; orked it down to four feet, and started for St. Paul at 3.30 p. m. Have t four feet of water on all the bars from Trempelean to Saint Paul. ve taken 69 cords of wood this week, and run 520 miles.

Sunday, August 23.—The engineers were quite busy most of the day aning and fixing the engines. Paid off the cook and carpenter and gaged others.

Monday, August 24.—Left St. Paul at 7 a. m.; found four feet scant Frenchman's bar, and three and a half feet on Pig's Eye; scraped e latter down to four feet, made an alteration in the sign and left at 0; found four feet scant at the foot of the island; Robinson's bar had ur feet and lower Grey Cloud but three and a half feet. Worked here out 1½ hour and made four feet. Ran down by Nininger's bar and nd but three and a half feet here; scraped till 2.45 and made four et; put up a sign-board below and went on down. Point Douglass r had four feet scant. Tied up for night at the head of the lake, aving run 65 miles and taken 10 cords of wood.

Tuesday, August 25.—Left Waconta at 5 a. m.; passed Reed's at 7.30,

and made Beef slough at 8.30. Sounded all the bars and found four feet, except on Tow-head crossing, which had four feet scant. Worked here till 10 a. m. Changed the guide on the left bank. Left at 10.35. Arrived at West Newton bar at 11.30. Found only four feet scant in channel. Began scraping here, (the first in this place.) Worked 2½ hours and made good four and a half feet. Put up sign and went on at 2.45 p. m. Found four feet scant on Rolling Stone. Scraped 30 minutes and made good four feet. Stopped at Winona for night at 7 p. m. Took 12½ cords, and ran 99 miles.

Wednesday, August 26.—Started from Winona at 6.15. Morning foggy. Arrived at Trempelean bar at 7.50. Found scant four feet of water. Scraped all the forenoon and left it with good four feet. Headed up again. Made Rolling Stone at 4.50. No perceptible change here since yesterday. Lay up at West Newton for night. Took seven cords wood. Ran 72 miles.

Thursday, August 27.—Started at 5 o'clock a. m. Made Beef slough at 6.35. Found the water had fallen two and a half inches since Tuesday, with four feet on lower crossing, four feet scant on middle, and on upper four feet on one side and four feet scant on the other. Met the Montana a little above the head of Beef Slough chute. Landed and took some lumber and a skiff from here and went on up. Got through the lake at 11 a. m. Wooded at Diamond bluff. It began to rain before we finished wooding and did not stop till we were at Prescott. Found four feet scant on Point Douglass bar, and but three feet large on Nininger. Worked here until sundown, and tied up. Have run 100 miles and taken 14 cords of wood.

Friday, August 28.—Began work again on Nininger bar at 6.10 p. m. Worked until 7.50, and had three and a half feet. Ran up to Grey Cloud and found but three feet there. Worked steadily on this bar till 1.15 p. m., and made good three and a half feet. The Muscatine got aground here about 11 o'clock, and was three quarters of an hour getting over. Examined the channel marked in sketch "channel used some," and found three feet on the crossing. The best water was very near last year's channel. [See blue lines on sketch.] Arrived at Pig's Eye 5.10. Found but three feet on the bar at foot of island and scant three on main bar. Water fallen five inches here since Saturday last. Scraped on last-mentioned bar till night and lay up here. Made quite an improvement in the soundings, intending to make thorough work here before leaving. Have made about 30 miles to-day, and taken 13 cords of wood.

Saturday, August 29.—River fell nearly two inches last night. Began work on Pig's Eye bar at 6.15 a. m., and scraped till 9.50. Made three and a half feet water in the crossing. Moved the guide-board down about 250 feet, and put up some to direct in making the crossing at the foot of the island. I examined this bar in the yawl, and found the channel had changed very much lately. [See sketch.] Ran down to Grey Cloud, arriving at 11.35. Found but three feet. Worked till 3.40 p. m., and left good three and a half feet. Started up river again. Made Pig's Eye at 6. Worked on the lower bar till after sundown. Reached St. Paul at 7.35 p. m.

A. R. RUSSELL, *Captain.*

APPENDIX D.

Captain N. F. Webb's report.

U. S. STEAMER MONTANA, *August* 31, 1868.

DEAR SIR: In 1867 Major General Warren requested Captain W. F. Davidson, President Northwestern Union Packet Company, to permit me to leave the command of the steamer Itasca and accompany him (General W.) during the low water of that season on this boat, (Montana,) and witness the operations and success or otherwise of Colonel Long's scraper, then introduced for the first time for the purpose of improving the navigation of the upper Mississippi, and also requested me to give my views in relation to the best method of working the scraper and the localities where it might be used to the greatest advantage.

Accordingly I was permitted to join General Warren early in October of the year referred to.

Previous to this time I had seen a model and drawings of the scraper, with which I was much pleased. I thought it might do good service on the bars, but after I had witnessed the practical operations of this machine at Beef slough and elsewhere I was highly gratified, as it certainly exceeded my expectations, both in the amount of work which it accomplished and the great facility with which it was raised and lowered on to the bars and made to perform the work required.

I remained with General Warren until the close of navigation, in November, witnessing the daily operations of the scraper upwards of six weeks, during which period it was used to the entire satisfaction of all concerned, and so simple and complete was the arrangement of all its parts and adjustments that no loss of time or delay was occasioned, by the necessity of making repairs or alterations, of any material importance.

On the 1st of February I was placed under your orders to assist in the care of the boats Montana and Caffrey during the winter, and the repairs and outfits of same for work during the next low-water season. For this purpose I repaired to Dubuque and remained there until the 6th of April, when I accompanied the boat to La Crosse, where the Caffrey was to be docked and both were to be repaired and receive their snagging apparatus.

On the 12th of July, acting under your instructions, I left La Crosse with the Caffrey for St. Paul, (see Appendix B,) and have made several trips on her since and witnessed her scraping operations on all the bars which required improvement between La Crosse and St. Paul. On some of the worst bars, such as Pig's Eye and Grey Cloud, we found three feet scant, but in every instance succeeded in increasing the depth to four feet, so that the agent of the northern line, Captain Buford, telegraphed for the large boats to come through to St. Paul, as they had been stopping at Prescott, 35 miles below, for want of sufficient water to enable them to cross the bars. The boats of this line and the Northwestern Union Packet Company have been running regular trips ever since—a condition of affairs never before known, at this stage of water, in the experience of pilots and steamboat men of thirty and thirty-five years' standing. There had been no large boats up to St. Paul for nearly six weeks previous to the operations of Long's scraper, and it is safe to say that they would not have been able to make the port of St. Paul without it, except by the greatest exertions, and at occasional intervals when there had been a rise in the river of five or six inches.

I beg leave to state that I have had 43 years' experience in the navigation of western rivers, having during that time commanded 30 different steamboats, partly on the Ohio, Cumberland, Tennessee, upper and lower Mississippi. The first boat I was connected with was the America, in 1824. I have always paid the greatest attention to the different methods proposed for improving navigation in the west, and, as far as my observation goes, have never seen a more efficient or economical plan than the one adopted in the use of Colonel Long's scraper.

The inhabitants of the west, and particularly those living on the banks of the upper Mississippi, are under great obligations to General Warren for his sagacity and good judgment in allowing the use of the Long scraper in the district under his command, and to yourself, for the energy and perseverance exercised in perfecting its operations and adaptations to western steamboats in the face of many drawbacks and discouragements.

Very respectfully, your obedient servant,

N. F. WEBB.

P. S.—Since writing the above, I have accompanied you on the Montana on a trip from St. Paul to Trempeleau and return.

The snagging and scraping apparatus of this boat meets every expectation. Three very dangerous snags were taken out at the head of Beef slough, two at Rolling Stone, and others in different localities. Some of these snags measured 40 feet long and three feet diameter above the roots, very heavy and directly in the main low-water channel. We also deepened the water to four feet at Trempeleau bar.

N. F. WEBB.

Major H. C. LONG.
United States Civil Engineer.

APPENDIX E.

Report of Captain D. S. Stombs, being extracts from log-book of United States steamer Montana.

Wednesday, August 26.—Lieutenant Chase's corps of engineers came on boat last night to go down with it. Had steam on at 5.30 a. m., and tried the nigger engines; found them working very satisfactorily. A ten-string raft of sawed lumber, in two sections, passed down the river about 6 a. m.; got under way at 7.30; made Frenchman's bar at 7.40; Pig's Eye 8; Picayune bar 8.45; Robinson's island 9.15: and Grey Cloud 10.50; took on ten cords of wood at latter place and went on; passed Point Douglass at noon; took on 13 cords of wood at Diamond Bluff, and left at 2.10, after leaving order with J. A. McConnell for some dimension oak lumber for wheel arms and floats for Montana and Caffrey; passed Redwing at 3.15 p. m.; entered Lake Pepin at 4.10; passed through at 6.35, and tied up at Wabashaw at 7.05. Boat came through without touching bottom, and was followed by the Key City with good freight and no trouble. Found water at good stage, four feet in channel. Strong wind up stream all day; weather warm. Took on 23 cords of wood during day, and ran about 112 miles.

Thursday, August 27.—Left Wabashaw at 6.30 a. m., going down; met Caffrey at Clara Hinde's wreck; stopped ten minutes to transfer lumber, and then dropped down into Beef slough and made first trial of snagging apparatus. Snag was just below head of slough, wholly under water and out of sight; made fast to it without difficulty and hauled it

to top of water with ease, the cranes working very steadily; rolled it to top of bank and then left. It was a black elm, full length, with roots measuring two and a half feet diameter at butt, and at 25 feet branching into two forks, each one foot diameter. Took out smaller snag from same locality, full length, one foot diameter and very crooked. Took a black oak log from the middle of channel a little above the others, at the very head of the slough, 17 feet long, two feet diameter at one end, 19 inches at the other.

Started down stream at 2.30 p. m.; stopped for half an hour at Minneiska for eight cords of wood, leaving at 4.30; landed at Rolling Stone wood-yard at 6.15 and tied up for the night, after taking 21 cords of wood. Heavy wind up river all day, and rain from four to six p. m. Ran 40 miles; shipped 29 cords of wood.

Friday, August 28.—Heavy shower last night; got off at 5.35 a. m.; passed Winona at 6.20 and made Trempeleau at 8.05; lowered scraper on bar at this place, made three scrapes, leaving good four feet, and headed up stream at 8.40 a. m., passing Winona at 10.55 and Fountain City at 12.15. At 1.45 stopped and took a snag from channel opposite next headland above Chimney rock, near Wisconsin side, measuring 25 feet in length and two feet in diameter at base, with roots. At 2.30 went on a mile or so and made fast to a bad snag in the middle of the channel at crossing below Mount Vernon, towed it down stream to left shore and hauled it upon bank out of harm's way. It was the trunk and roots of an elm, 38 feet long, and 36 inches diameter at base. Got under way again, and after a rough, windy afternoon, tied up at Rough island at 7 p. m. Took 16 cords of wood here, and ran during day 85 miles.

Saturday, August 29.—Got under way at 4 a. m., going up; made Beef slough at 5.35 and Wabashaw at 6.35; landed here and sent yawl out to make fast to a snag in the middle of channel; found it loose and towed it ashore. It was a log of about 18 feet long and two feet diameter at large end.

Left Wabashaw at 8 and entered lake at 9 under a strong head wind and heavy sea; made head of lake at 11.50, Redwing 12.50 p. m., Point Douglas 4, Hastings 5, and Grey Cloud at 7. Took 13 cords of wood and left at 7.35; reached Pig's Eye about 11; found the War Eagle grounded there and swung across channel with heavy load on and two loaded barges on either side.

Concluded to cross to left bank and lie-to till she got away; struck the reef a little too high up and got stuck, the stern swinging round. Got out a line and pulled off. War Eagle got off in about two hours; went on after her. Found three and a half and four feet on bar, and after getting over it a heavy fog shut down on us, and we tied up for the night at one o'clock. Ran 110 miles. Took 13 cords of wood.

Sunday, August 30.—Heavy fog this morning; got under way at 7.30 a. m. Met Caffrey just above Frenchman's bar, coming down per order of Major General Long, sent up during night. Directed her to scrape a few hours at Pig's Eye. Landed at St. Paul at 8.10; Caffrey got up about 10.30. Found water six and a quarter inches lower than we left it on Wednesday.

D. S. STOMBS, *Captain.*

CHAPTER V.

History of the improvement being carried on on the Minnesota river.

The following is an account of the operations under the appropriation of $37,500 for removing snags and boulders from the Minnesota river.

On the 22d of June, 1867, the following advertisement was inserted in the Saint Paul Press, daily, from June 23 to 30; Saint Paul Press, tri-weekly, from June 30 to July 6; Saint Paul Pioneer, daily, from June 23 to June 30; Saint Paul Pioneer, tri-weekly, from June 30 to July 6; Minnesota Staats Zeitung, weekly, from June 29 to July 6; Dubuque Times, daily for one week; Wisconsin State Journal, daily for one week; Chicago Tribune, daily for ten days; Cincinnati Times, daily for seven days; Pittsburg Commercial, daily for seven days:

UNITED STATES ENGINEER OFFICE
Saint Paul, Minnesota, June 22, 1867.

Sealed proposals in duplicate will be received at this office, addressed to the undersigned, until 12 m. Thursday, July 25, as follows:

Proposals for removing snags and boulders from the channel of the Minnesota river.

This work is in two sections; the *upper section*, from the junction of the Yellow Medicine river to Mankato. 133 miles, has reefs of small and large boulders, and snags singly and in groups. The width is about 200 feet, the low-water channel-way 20 to 40 feet wide, with depth from 10 to 24 inches, and current half to two and a half miles per hour. The *lower section* being from Mankato to the Little Rapids, 61 miles, is mainly obstructed by snags. The width is about 250 to 300 feet; to low-water channel-way 40 to 80 feet wide, with depth from 15 to 20 inches, and current one to two miles per hour. The Little Rapids at low water can only be passed by light vessels of one foot draught, with a rise of four feet, these rapids are no obstruction.

The banks throughout the river are generally alluvial, from 10 to 20 feet above low water. By the term snag is meant sunken logs and stumps, and trees with roots imbedded in the bottom of the stream. They vary in diameter from one-half to three and a half feet. The boulders will not require stronger lifting machinery than the snags will, and may be deposited in deep holes: but snags must be destroyed and placed where they cannot again wash into the channel-way. The work will be let entire or in such parts as the engineer may determine. $37,000 is appropriated for this work.

Contractors will state the price of removal per snag of the following diameters above the root: First, between 6 and 20 inches; second, between 20 and 30 inches; third, between 30 and 36; fourth, between 36 and 42 inches. The price of removing boulders will be stated by the ton or cubic yard.

Contractors will be required to furnish their own boats, machinery, &c., as well as labor; to interfere as little as practicable with navigation, and to show that they possess the necessary skill and experience, and that the means to be used are adapted to the river, and suitable in construction and mechanical power. They will be required to commence work at two points at least by the 1st of September next, the stage of water permitting. These proposals must be indorsed on the envelope: "Proposals for removing snags and boulders from the Minnesota river."

* * * * * *

A printed copy of this advertisement must be attached to each proposal herein solicited. Each bid must contain a written guarantee, signed by two responsible persons. Blanks for proposals will be furnished at this office on application. The government reserves the right to reject any and all bids.

Parties desiring further information can obtain the same by calling at this office, where maps of the river and drawings of vessels for removing snags and boulders will be shown to all who desire to make proposals.

G. K. WARREN,
Brevet Major General U. S. A., Major Engineers, in charge.

Abstract of all proposals received at Saint Paul, Minnesota, July 25, 1867, for the removal of snags and boulders from the channel of the Minnesota river.

No.			Snags, diameter in inches.				Boulders.	Remarks.
			6 to 20.	20 to 30.	30 to 36.	36 to 42.		
1	Patrick Nash....	Geo. L. Becker, and A. Goodrich.	$14 00	$14 00	$14 00	$14 00	$10 00	*Upper section.
			13 00	13 00	13 00	13 00	10 00	*Lower section.
2	Sanf'd A. Hooper.	Robert H. Rose and A. G. Chatfield.	4 95	6 00	7 50	11 00	4 90	Both sections.
3	C. R. Read.....	Thomas Wilson....	10 00	13 00	16 00	20 00	2 50	†Both sections.
4	Jos. Walker and Wm. Hardy.	C. D. Gilfillen and J. B. Lyge.	8 95	11 95	13 95	16 95	.....	Boulders, $10 per ton.
5	Reynolds, Saulpaugh & Co.	Horace Thompson and N. B. Harwood.	12 50	15 50	20 00	23 00	.....	Boulders, $6 per ton.
6	D. H. Fawles....	J. S. Walker and Wm. A. Gaslin.	25 00	32 00	38 00	50 00	30 00	Upper section.
			23 00	30 00	35 00	45 00	30 00	Lower section.
			23 00	30 00	35 00	45 00	27 00	Both sections.

*Upper section, from junction of the Yellow Medicine river to Mankato; lower section, from Mankato to ule Rapids.
†Snags and boulders bid for together, not separately.

I certify this to be a true copy of the original bids.

G. K. WARREN,
Brevet Major General U. S. A., Major Engineers.

The contract was awarded to Samuel A. Hooper July 25, 1867; signed uly 27, 1867, and approved by the department.

The following is a copy of an indorsement of Sanford A. Hooper:

We, the undersigned, residents of Minnesota valley and of the city of Saint Paul, being rsonally acquainted with S. A. Hooper, have no hesitation in recommending him as pos-ssed of the necessary energy, skill, and experience, and also of pecuniary ability to per-rm the work of removing snags, boulders, &c., from the channel of the Minnesota river, greeably to your advertisement under date of June 22, 1867, soliciting proposals for such work.

Respectfully yours,

J. M SPRAGUE.
ROBERT H. ROSE.
ADAM BUCK.
T. J. DUFFY.
D. L. HOW.
F. L. BALCH.
D. A. HUNTSMAN.
L. L. BAXTER.
R. BLAKESLY.
HORACE THOMPSON.
CHARLES SCHEFFER.
J. C. BURBANK.
A. G. CHATFIELD.
ROBERT A. IRWIN.
D. D. CHATFIELD.
FRIEND J. WHITLINK.
S. A. PARKER.
E. FARNHAM.
SPICY, BLACK, & Co.
STONE, METZNER & Co.
J. W. BISHOP,
Chief Engineer M. V. Railroad.
SAMUEL BOWLER.
CHARLES BERRY.

G. K. WARREN,
Brevet Major General U. S. A.

Mr. Read's bid for removing boulders could not be accepted, as is hown by the following communication:

SAINT PAUL, *July* 25, 1867.

GENERAL: In making the proposal for removing snags and boulders from the Minnesota er, it was my understanding that the bid was made as a whole, and not liable to be epted in part only. Thus, for instance, that my offer for removing boulders at the price ted, was only on condition of having also the work of removing snags at the price I ted.

C. R. READ.

Witness:
H. C. LONG.

eneral G. K. WARREN, *Major of Engineers.*

I certify that the above is a true copy of the original.

G. K. WARREN,
Brevet Major General U. S. A., Major of Engineers.

Subsequently, Mr. C. R. Read sent to the department a protest against the approval of my award of the contract to Mr. S. A. Hooper, which was referred to me and a report upon the facts in the case requested. The report was made and forwarded to the department, since when nothing has been heard of the matter.

Mr. Hooper having reported that he would be ready with one crane boat to commence removing snags by August 20, Captain Edwin Bell was appointed inspector of the work August 19, 1867. The following is a copy of letter of appointment and instructions:

UNITED STATES ENGINEER OFFICE,
St. Paul, Minnesota, August 19, 1867.

CAPTAIN: I hereby appoint you to assist me in superintending the removal of the snags and boulders from the Minnesota, under the contract made with Sanford A Hooper.

The terms of the contract are as follows: That the said Sanford A. Hooper shall remove from the channel of the Minnesota river, between the Little Rapids and the Yellow Medicine river, at such points as the engineer in charge may direct, such snags, sunken logs and stumps, and trees with roots imbedded in the bottom of the stream, and such boulders as said engineer may designate, and dispose of them to the satisfaction of said engineer, so that they cannot again obstruct navigation; shall furnish his own apparatus for doing the work, and all the labor, material, and subsistence required in doing the same; and do this at the following prices, viz:

1st. For logs, stumps, and trees, above described, of the following dimensions, measured one foot above the root; for those of 6 inches diameter and upwards, not exceeding 20 inches, each $4 95; for those of 20 inches diameter and upwards, not exceeding 30 inches, each $6 00; for those of 30 inches diameter and upwards, not exceeding 36 inches, each $7 50; for those of 36 inches diameter and upwards, not exceeding 42 inches, each $11.

2d. For bolders, per cubic yard, $4 90.

That all the work performed, offered under this contract, shall, before being accepted, be subject to a rigid inspection by an inspector appointed on the part of the government, and such as does not conform to the specifications set forth in this contract shall be rejected.

The engineer's estimate of the different kinds and amount of work in the several parts of the river are as follows:

From Yellow Medicine river to Red Wood river, distance 27½ miles, 1,400 cubic yards rock, 50 snags; from Red Wood river to Fort Ridgley, 28¼ miles, 250 cubic yards rock, 300 snags; from Fort Ridgley to Mankato, distance 72½ miles, 70 cubic yards rock, 650 snags; from Mankato to Le Sueur, distance 30¾ miles, 180 cubic yards rock, 700 snags; from Le Sueur to Little Rapids, distance 43 miles, 120 cubic yards rock, 300 snags.

Your duty will be to designate what snags, (including in them stumps and logs,) and what rocks must be taken out, and the manner of disposing of them, and to measure them according to the manner prescribed in the contract, and keep a record in the manner shown in the accompanying note book.

It is not contemplated to remove every obstruction in the river, but to make the money go as far as possible in clearing the river, so as to make it passable, doing that most needed first. You must, therefore, decide how far to carry on the work at any one point, according to your own judgment of the requirements of navigation.

You must, at the same time, as far as possible, arrange the work so as to be convenient to the contractor, allowing him to remove, while at one place, all that you intend to have removed, and also requiring him to do this, if the stage of water permits.

One-third the measure around a snag will be a fair way to get its diameter. The length, breadth, and thickness of the boulders will be taken, from which the whole contents will be calculated.

On Mr. Hooper's statement of work done, duly certified by you as correct, payments according to contract will be made by me. Your field of operations will extend from Little Rapids to Mankato.

Yours, respectfully,

G. K. WARREN,
Brevet Major Gen. U. S. Army, Major of Engineers.

Captain EDWIN BELL.

UNITED STATES ENGINEER OFFICE,
St. Paul, Minnesota, August 19, 1867.

CAPTAIN: Your compensation while in my employment will be $125 per month, and your expenses. On the river you will be allowed a man, or two men, as may be necessary, from $30 to $45 per month, if worth that amount.

You will be supplied with a skiff and tent; and in procuring your subsistence you will be expected to confine the cost within 75 cents per day, on the average, for each of your party.

Yours, respectfully,

G. K. WARREN,
Brevet Major Gen. U. S. Army, Major of Engineers.

Captain EDWIN BELL.

The following are extracts from the report of Captain C. E. Davis, C. E., (dated September 20, 1867,) who had been sent to make an inspection of the whole river. This report shows a great increase of the number of snags over his report of 1866. This increase is doubtless due to the flood of 1867.

* * * * * * * *

This stream (Blue Earth river) has been very high, and about 70 feet of the right bank has been washed away. The ferryman informed me that the river was full of snags and trees, which were running for four days, and he estimated that about one thousand trees went out of all sizes. A considerable number of these trees lodged on the gravel bars at the mouth of the Blue Earth, while a much greater number passed down the Minnesota river.

The greater portion of these trees came from the Le Sueur river into the Blue Earth, and it is estimated that about four acres of heavy timber, principally cottonwood, elm, and soft maple, were washed from that stream during this last season.

The Little Cottonwood river was very low, but it had been high, and brought down trees and drift. The Big Cottonwood had been very high, and the bridge across it had been carried away; but at present this stream is very low. During the high water a considerable number of trees was brought down.

* * * * * * * *

While on this examination, I visited the snag-boat at work on the Minnesota river, and also that portion of the river for about three miles below the point at which the party were at work. and I find the number of snags is greatly in excess of the number reported in the result of the examination made last year. This is mostly owing to the large number of snags brought into the river during the high water of this year. The channel of the Minnesota river, where the snag-boat has been operating, has been cleared of all obstructions, with the exception of two snags. which, after a fair trial, it was considered impossible to remove without the assistance of greater power. Most of the snags and trees lying on the slope of the bank of the river, or near the bank, and which were considered dangerous to navigation, have been removed, the result of which is a very great improvement to the navigation of the river.

In conclusion, I would remark that from the best information I could obtain during the recent examination, about 1,500 trees and snags have been carried into the Minnesota river by its tributaries, principally from the Blue Earth, which has contributed nearly if not quite 1,000. The Cottonwood from 200 to 300, and the upper tributaries, from 200 to 300. This will, I believe, include all that have been washed from the banks of the Minnesota river, and it is my opinion that the greater portion of these snags are deposited in that portion of the Mtnnesota river between the mouth of the Big Cottonwood and the town of St Peters.

I also made a hasty examination of the channel of the Minnesota river from Mankato to the mouth of Blue Earth river, and find that some bars have formed, while others have been washed out and that a considerable number of trees and snags have been deposited in this portion of the river.

About the first of October, a second crane-boat was completed. These boats are scows, such as are used on the upper Mississippi and Minnesota rivers for boating wood, &c., with the addition of strengthening timbers and a deck; upon this deck the crane is placed; they are about 60 feet long, 17 feet wide, and draw eighteen inches with crane, &c., on them.

The contractor, being anxious to further operations, asked permission to put on a party to work from the shore; his request was granted, and (October 3) Captain O. H. Maxwell was appointed to superintend the operations of this party; his instructions were the same as given to Captain Bell. This party worked from Belle Plaine down river.

The utility of the work done by this party proving questionable, its operations were discontinued by me about the first of November. Work with the crane-boats continued to be prosecuted under the supervision of Captain Edwin Bell, until stopped by the cold, November 23, 1867. The river closed November 28.

In prosecuting operations during the season of 1867, the work was

frequently impeded by leaning trees on the banks: these trees were not only a present obstruction to navigation, but were liable to become a greater one by the banks washing away and letting them fall into ther iver. Besides these, which did not come under the terms of the contract, there were in the ravines, and along the banks of the tributaries, a large number of fallen trees, which the next high water would bring into the Minnesota, where they would become snags of the most troublesome kind.

In view of these facts, a party of ax-men were employed during the winter months, under the supervision of Captain Edwin Bell, in removing leaning trees along the banks, and such as were likely to be washed in by high water, from Mankato down. The result of their operations will be found appended to this report.

Statement showing the number and size of trees cut from the banks of the Minnesota river and tributaries by party under Captain Edwin Bell.

Locality.	Diameter in inches.				
	6 to 20.	20 to 30.	30 to 36.	36 to 42.	Over 42.
First reach below Mankato	40	10	8	4	
First bend below Mankato	12	9	5	.....	
Second and third bend below Mankato	32	14	16	1	
Sliding Bluff	21	4	4	.....	
Reach below Sliding Bluff	41	2	7	1	
Dutchman's Bend	47	13	14	4	
Hurricane Bend	3	4	.....	.....	
Reach below Hurricane Bend	34	5	.....	.....	
First bend below Hurricane Bend	32	8	5	3	
First bend to Cedar Bend	120	37	12	3	
Long bend, below Cedar Bend	159	15	7	2	
First bend above Cottonwood Bar	158	49	20	.....	
Cottonwood Bar	75	60	.....	.....	3
First bend above Young's Bar	145	20	20	.....	
Young's Bar	15	.....	.....	.....	
Oleson's Bend	119	70	40	.....	
Long bend below Lime Kiln	36	50	.....	.....	
Long bend and reach below cut-off	38	20	30	.....	
Reach above Kasota	30	17	20	8	
Kasota Rock bend	52	40	24	6	5
Whirlpool Bend	98	30	12	13	4
Bend above Kasota Ferry	51	24	25	27	3
Kasota Ferry	35	15	10	1	
Butler's to Traverse de Sioux	25	15	5	.....	
Travers de Sioux, Roberts's warehouse	45	15	5	2	1
Roberts's Ferry bend	20	.....	10	10	5
Bend above Ottawa	15	5	5	4	5
Bend below Ottawa	25	15	4	3	3
From bend below Ottawa to Weise's Landing	50	16	10	.....	
From Weise's Landing to Webber's Landing	25	36	18	5	2
From Webber's Landing to Hunsucker's Bend	40	20	12	5	
Hunsucker's Bend	75	10	15	5	5
Hunsucker's Bend to Upper Le Sueur	30	10	20	5	
Upper Le Sueur to Lasher's Ferry	75	35	20	3	2
Lasher's Ferry to Devil's Elbow	190	70	30	18	3
Devil's Elbow to Horse Shoe Bend	205	200	55	44	
Horse Shoe Bend to High Island creek	150	100	30	25	4
High Island Bend to first bend below Keystone	80	70	25	20	
First bend below Keystone to bend above McCormick's	80	50	25	35	
Total	2,518	1,183	568	267	45

Statement of number and size of snags removed from channel of Minnesota river by S. A. Hooper, under contract awarded him July 25, 1867.

Locality.	Diameter in inches.					
	4 to 6.	6 to 20.	20 to 30.	30 to 36.	36 to 42.	Over 42.
Dutchman's Bend	50	386	72	9	3	
Hurricane Bend	26	1,238	84	16	4	2
Bend above Belle Plaine	.....	9	5	....	....	3
Lower Belle Plaine	1	48	9	2	....	
Upper Belle Plaine	.....	443	33	17	2	
Pigeon Bend	.....	161	7	....	....	2
Farris Bend	.....	123	8	4	....	1
Faxon Bend	.....	107	15	1	....	1
Keystone Bend	.....	124	8	1	1	
Total	77	2,639	245	50	10	9

Statement of number and size of snags removed from channel of the Minnesota river this year, prior to September 1, by S. A. Hooper.

Locality.	Diameter in inches.					
	4 to 6.	6 to 20.	20 to 30.	30 to 36.	36 to 42.	Over 42.
Bend below Lower Belle Plaine	.....	6	1	....	....	
Bend above Lower Belle Plaine	.....	15	9	1	1	1
Bend below Upper Belle Plaine	.....	10	2	1	1	
Bend above Upper Belle Plaine	.....	8	1	1	....	1
Bend above Roberts's Creek	.....	25	5	1	....	
Bend below Beaver	.....	5	3	....	....	
Beaver Bend	.....	5	1	1	....	
Bend above Beaver	.....	8	2	....	3	
Bend below Faxon	.....	27	5	2	3	1
Faxon Bend	4	18	7	2	....	
Bend above Faxon	3	32	7	....	1	2
Blakely Bend	4	35	23	4	4	5
McCormick's Bend	7	34	8	1	2	3
Sliding Bluff Bend	17	137	31	6	7	5
Keystone Bend	13	118	20	6	2	2
High Island Creek Bend	15	157	20	9	2	5
Sliding Bluff (No. 2) Bend	30	277	46	7	8	
Total	93	917	191	42	34	25

Statement of whole number of snags removed from Minnesota river, by S. A. Hooper, up to this date, (September 1, 1868,) and amount paid for same.

	Diameter in inches.	Price.	Amount.
170 snags	4 to 6	$0 75	$127 50
3,556 snags	6 to 20	4 95	17,602 20
463 snags	20 to 30	6 00	2,616 00
92 snags	30 to 36	7 50	690 00
44 snags	36 to 42	11 00	484 00
34 snags	Over 42 in.	.....	625 47
Boulders	58.13 c. yds.	4 90	284 85
Amount paid, $22,430 02, less 10 per cent, $20,187 02	.....	.....	22,430 02

Besides this amount paid to Mr. Hooper, the contractor, there has been expended under direction of Captain E. Bell, my assistant and inspector, for cutting down impending trees and for the expense of his own party, in supervising the work, and for further examinations and drawings under my other assistant on this work, altogether, $5,859 13; so that there remained unexpended, September 1, only $9,210 85 of the original appropriation of $37,500.

The amount left will all be expended with favorable weather this season; and it is believed will nearly clear the river as far up as Mankato. The number of snags to be removed proves to be more than double the first estimate. An additional appropriation of $20,000 is asked for to carry on the removal of snags above Mankato.

An appropriation, too, is solicited to enable us to make a practical passage at the Little Falls; $30,000 is deemed ample for this purpose, and it will then make fully available all that has been done above it. This estimate was in our first estimates, but not acted upon.

Captain Edwin Bell, who has personally supervised this work, has acted with great steadfastness and zeal. He has not escaped the charge of having been too exacting, but he has only carried out my instructions; and whatever there has been wrong in them is my fault. Mr. Hooper, the contractor, too, though claiming he had not a fair interpretation of his contract, has earnestly carried on his work.

For myself, I hope to be relieved hereafter from conducting such work by contract, because too much has to be given to my discretion, and while I am protecting fully the interests of the public, I may be too exacting upon the contractor, notwithstanding I have but the single desire to do what is just to all parties.

CHAPTER VI.

Detailed estimates for the improvement of the Wisconsin river and Fox river line.

These estimates have been prepared by Captain D. W. Wellman and his assistants, under my direction, and are as perfectly expressive of my views as if made solely by me. I have therefore made his report on the estimates a part of this chapter.

We do not think the navigation of these upper rivers "for commercial purposes" will require a greater draught through the canal than four feet, and have based our recommendations accordingly. An estimate is made

for a canal of five feet draught, which will cost about $397,500 more than the one of four feet draught. An addition of $500,000 would make a canal of six feet draught, if for any "naval purposes" it might be deemed desirable to make it. It is practicable to make here a canal of any size, the supply of water being ample and all excavations in sand. In order to make the estimates for the route complete from the Mississippi to Green bay, I append here the estimates made in 1866 by Major Suter for the route along the Upper and Lower Fox rivers. At the end of this chapter, too, I have given a map and profile, which is a revision of the one rendered with our first report. (H. Ex. Doc. No. 58, 2d sess. 39th Cong.)

Major Suter reports the condition of the improvements on the upper and lower Fox rivers as needing considerable repairs, in order to secure the full benefits of them on their present scale of four feet draught, and locks 160 feet by 35 feet, and presents an estimate of the required amount. He estimates, also, the additional expense to obtain six feet draught, with locks 220 feet by 35 feet. His estimates are as follows, and meet my approval:

FOR LOWER FOX RIVER.

Place.	For four feet draught.	For six feet draught.
Menasha	$13,270 00	$54,200 00
Appleton	18,870 00	74,870 00
Cedar	3,930 00	23,450 00
Little Chute	7,530 00	77,200 00
Grand Kaukauna	22,800 00	111,670 00
Rapide Croche	4,000 00	41,000 00
Little Kaukauna	3,000 00	27,730 00
Depere	45,000 00	83,300 00
Total	118,400 00	493,420 00

FOR UPPER FOX RIVER.

Location.	For four feet draught.	For six feet draught.
1st level	$9,400 00	$31,400 00
2d level	71,673 00	151,873 00
3d level	67,400 00	114,888 00
4th level	92,856 00	217,363 40
5th level	40,000 00	88,466 00
6th level	4,693 00	50,505 00
7th level	40,000 00	80,600 00
Total	326,022 00	735,095 40

The Improvement Company allowed us to take copies of the maps and plans of their works to aid us in making the above estimates.

Report of Captain D. W. Wellman, giving estimates for the improvement of the Wisconsin river.

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., September 5, 1868.

GENERAL: In compliance with verbal directions from you, received on the 20th ultimo, I have the honor to submit herewith the result of

my investigations as to cost of improving the Wisconsin river from Portage City to the mouth, so as to render it navigable for steamboats drawing from three to five feet of water.

The data for the estimates have been taken from the maps and notes of the survey of the Wisconsin river made last year under Brevet Major C. R. Suter, United States army, for whom I acted as principal assistant, and from my own personal observations made at the same time. I have estimated:

1. For improvement of the natural channel of the river, for three feet navigation, by means of a series of wing dams and use of Long's scraper.

2. For four feet navigation, by use of natural channel, old beds, and side canals built around shallow portions of the river.

3. For a canal with five feet navigation; the canal to be built along the river banks, changing from side to side of the river to keep on most advantageous ground, selecting convenient places in the river for crossings

I have made no estimate for slack-water navigation in the river itself, by means of locks and dams, for the reason that the river flows the entire distance through bottom lands of alluvion, and over beds of movable sand, and it is a matter of much doubt whether or not dams in such a stream could be made permanent at any practicable expense. This, added to the fact that the slope of the stream is so great (about one foot five inches to the mile) that dams would be required every four or five miles, seems to settle the question at once against this method of improvement.

The estimates have been prepared with as much care as the time would permit, and are believed to be as nearly reliable as can be made without an extended survey for that purpose of all the different localities.

Of the first plan I would say that I consider it entirely practicable, and that the cost cannot exceed the estimate here made. I do not, however, think that over three feet in low water can be calculated on by this plan. The commerce must be carried on by means of small tugs and barges; the channel will be crooked and the current rapid, and there will at times necessarily be considerable delay to boats for want of the requisite scraping in various places; and it may be a question, after all, whether a navigation of this sort will meet the requirements of the country through which it passes, and of the vast region west of it, and from which a large share of its business will necessarily be derived.

These difficulties will be in a measure obviated by the adoption of the second, and entirely so by the adoption of the third plan here submitted, thus securing at lowest water a navigation of four or five feet, sufficient, probably, for any boats likely to run on the upper Mississippi for many years to come.

The objection to the *second* plan is, the greater number of locks to tend and keep in repair, and the liability of the portions of the river used for navigation to *change during floods* so as to necessitate the expenditure of large sums of money in dredging and other works, in order to maintain in its place a deep river channel.

For my own part, from the information we now have, the *third* plan, of a canal the entire distance, modified for navigation by steamboats of four feet draught, seems to be preferable to any of the others, for several reasons:

1. Its cheapness as compared with canals generally. Though the estimates may appear small, it must be borne in mind that nearly all the work is *excavation*, and that in sand and loam, and that with proper machinery it may be done at a very small cost.

2. The small comparative cost of maintenance when once completed. The canal embankment, as estimated for, will be entirely above high-water mark in the river, and consequently never liable to damage by floods; also, the design is to so locate it that it will be on the opposite side of the river from the mouths of all the principal affluents, so that the guard locks alone will always regulate the quantity of water in the canal, and consequently the pressure upon the same; and, besides, the large surplus of excavation which will be wasted on each side will so increase the stability of the embankments that the danger of breaks from any source need scarcely be apprehended.

Again, there need be no estimate made for expense of *feeders*. The Wisconsin river, as shown in the estimates, will constitute a *natural* feeder with an almost unlimited supply of water. The daily discharge of water in the Wisconsin at Portage City in times of extreme low water has been determined by a series of careful observations to be more than 259,000,000 cubic feet; not less than 3,000 cubic feet per second. The total daily supply of water for the Erie canal of Pennsylvania, enlarged with a prism greater in area than the one here proposed, is less than 20,000,000 cubic feet—about 231 cubic feet per second—not one-twelfth of the amount available in the Wisconsin, and yet it is estimated that the Erie canal, just alluded to, which is 136½ miles in length, and has a lockage of 926 feet, has sufficient water to pass through the locks 144 boats per day, or to carry during the boating season 5,400,000 tons of freight.

The flow of water in the Wisconsin is so regulated by its passage through the Dalles—a gorge in the rock about 23 miles above Portage, which reduces the width of the river in one place to 54 feet—that the extreme of fluctuation from low to high water below the Dalles does not exceed 10 feet, and arrangements could easily be made, besides supplying the proposed canal with water, for turning any desired quantity at any time into the Portage canal and Fox river.

From what is here shown, it appears evident that this proposed canal, in connection with the "Fox river improvement," will afford a thoroughly reliable water communication from the Mississippi to Lake Michigan, capable of transporting millions of tons annually, at comparatively small cost. It will be seen, also, that aside from the item of *expense*, this route will afford facilities for the transportation especially of heavy freights, unequaled by any existing or proposed route. North of the Rock Island rapids, in the Mississippi river, the boats to be used should be of a class that can be loaded at any elevator on the Mississippi, or its navigable tributaries, below the Falls of St. Anthony, and go through the lake without breaking bulk.

A comparison of tariffs by various lines of transportation shows that freights can be carried by such a line as is here proposed, for about one-fourth of what they can by railroad. This fact alone, when the immense and continually increasing amount of grain annually shipped to the east, from west of the Mississippi, is taken into consideration, seems to demonstrate the necessity of its immediate construction.

Summary of estimate for improvement of the Wisconsin river from Portage City to the mouth.

First. For its improvement, by means of a series of wing-dams, &c., and use of Long's scrapers, so as to make it navigable for boats drawing three feet of water:

Sixty-five wing-dams, as per detailed estimate	$213,907 50
Add for additional dams, the necessity of which will probably appear hereafter, 50 per cent	106,953 75
Riprap on heads of islands and in bends of river, as per estimate	50,000 00
For cutting overhanging timber	3,000 00
For operating scraper and snag-boat one year, say	15,000 00
	388,861 25
Add contingencies for engineering, 10 per cent	38,886 12
Total	427,747 37

In addition to this estimate there will be the annual expenses for repairs of dams, say	$10,000 00
And for operating at least one scraper boat	15,000 00
Total	25,000 00

Second. For improvement, by use of natural channel in connection with side canals—70 feet wide on the bottom and 80 feet wide at water surface, with sides of cuts paved—of sufficient depth for steamboats drawing four feet of water:

4,132,725 cubic yards excavation, (all sand,) at 10 cents per yard	$413,272 50
391,095 cubic yards embankment, (all sand,) at 40 cents per yard	156,438 00
639,029 cubic yards embankment, (in river,) at $1 per yard	639,029 00
44,490 cubic yards riprap on embankment, at $2 50 per yard	111,225 00
Paving sides of channel, so as to use steamboats, 67 miles, at $7,000 per mile	469,000 00
Riprap at 16 guard-locks, 400 cubic yards each, at $2 50 per yard	16,000 00
Thirty-eight composite locks, at $25,000 each	950,000 00
10,000 feet of wing-dam, at $7 13 per foot	71,300 00
Sixty miles grubbing and clearing, at $400 per mile	24,000 00
Three railroad crossings, (draw-bridges,) at $10,000 each	30,000 00
Ten road crossings, at $2,000 each	20,000 00
Operating dredge and snag-boat one year	15,000 00
	2,915,264 50
Add for land damages, contingencies, and engineering, 10 per cent	291,526 45
Total	3,206,790 95

To the above is to be added, for maintaining navigation—the expense
lock and bridge tenders and of keeping in repair and operating prob-
ly two dredge-boats, to prevent the accumulation of sand around the
ard locks and for dredging in the canals themselves—say $50,000 per
num.

n case of improvement of this river there will be—

	Miles.
navigation in excavated canal	67
navigation in river	27
navigation in old beds and other natural channels	24
Total distance	118

otal amount of fall to be overcome by locks by this plan, 138 feet.

hird. For improvement by means of a canal—70 feet wide on the bottom
80 feet wide at water surface, sides paved for using steamboats—
t along the valley, alternating from one side of the river to the other
ircumstances demand, in order to avoid perpendicular bluffs or large
ams, and using the natural bed of the river for crossings, designed
teamboats drawing five feet of water:

92,000 cubic yards excavation, (sand and loam,) at) cents per yard	$1,269,200 00
000 cubic yards embankment, (in river,) at $1 per yard	640,000 00
ing sides of canal, 90 miles, at $7,000 per mile	630,000 00
00 cubic yards riprap on embankment, at $2 50 per ard	125,000 00
rap for 10 guard locks, 500 cubic yards each, at $2 50 r yard	12,500 00
nty-two lift locks, at $30,000 each	660,000 00
guard locks, at $25,000 each	250,000 00
miles grubbing and clearing, at $400 per mile	40,000 00
e railroad crossings, at $10,000 each	30,000 00
nteen road crossings, at $2,000 each	34,000 00
00 feet of wing-dam, at $8 per foot	80,000 00
rating dredge-boat one year	15,000 00
	3,785,700 00
for land damages, contingencies, and engineering,) per cent	378,570 00
Total	4,164,270 00

this, as in the second plan, must be added for maintaining naviga-
, the annual expense of lock and bridge tenders, for dredging, and
irs, say $60,000.

e locks in this, as well as in the second estimate, are designed to be
ame size as those already in use on the Fox river—160 feet in length
35 feet in width, and to have a lift as near as practicable of 8 feet
. This lift in some cases will probably have to be varied somewhat,
nding upon the length of the section between river crossings.

e total fall to be overcome by locks by the last proposed plan will
bout 175 feet.

e guard locks should be constructed so as to be used as lift locks in
s of high water in the river.

the river itself at each of the crossings will constitute a feeder, the
ly of water will be abundant and constant, and no allowance need

be made for leakage. Indeed, the size of the canal may be increased to almost any required capacity, with the certainty that there never will be any lack of water.

By constructing a canal on the third plan for four feet navigation, the estimate would be reduced, nearly as follows:

For excavation	$162,500 00
For paving	125,000 00
For locks	110,000 00
Total reduction of expense	397,500 00

Should the first proposed plan be adopted, and the whole of the necessary means be made available by the 1st of March, 1869, the entire improvement might be completed by September, 1870, or so nearly so that through navigation on the route could commence by the time the grain crop of that year was ready for market.

In case the second or third plan should be adopted, the most economical expenditure of the money will be by being able to commence work simultaneously along the whole line, and to carry it on without interruption to its completion.

To do this, at least one-half the estimated cost (say $1,603,000 for the second, or $2,082,000 for the third) should be appropriated to commence with. If this amount could be had by the 1st of March or April, 1869, the balance should be available by the 1st of August, 1870, and the canal might be ready for use by the autumn of the following year.

Very respectfully, your obedient servant,

D. W. WELLMAN,
C. E. in charge Wisconsin River, Inspector.

Brevet Major General G. K. WARREN.

[Here, in the original, belongs the map and section of Wisconsin and Fox river, showing improvement for connecting the Mississippi river and Green bay, prepared to accompany the report of Brevet Major General G. K. Warren, major of engineers.]

CHAPTER VII.

Table of ports of entry, collection districts, and amounts collected, during the last fiscal year.

The following table contains the names of the different rivers, the collection districts in which they are situated, the nearest port of entry, and the amount of revenue collected during the last fiscal year.

I give them as required by my instructions, but not as an indication of the value of the commerce benefited by the improvements proposed.

Work.	Collection district.	Nearest post of entry.	Rev. collected.
Minnesota river	Minnesota	Saint Paul	$12,406 32
Mississippi river	Minnesota	Saint Paul	
Wisconsin river	Galena	Galena, Illinois	
Mississippi river	Galena	Galena, Illinois	
Mississippi river	Dubuque	Dubuque, Iowa	

The comparatively small amount of revenue collected at St. Paul this ar is owing to the fact that the railroad iron used here this year paid ties at other ports, which was not the case in 1866.

CHAPTER VIII.

presentation of the public importance of these river improvements, as required by the joint resolution of Congress approved July 27, 1868, with map.

The joint resolution of Congress approved July 27, 1868, requiring a full statement of all the facts tending to show to what extent the neral commerce of the country will be promoted by the several works improvement," I venture the following general consideration relat- g to the subject. I have kept in view mainly the moving of the wheat op, but it is safe to say that in no case is the benefit of improved navi- tion which this shows more than one-half of what would result from nsportation of all kinds of products combined.

The region of the upper Mississippi is pre-eminently adapted to the oduction of wheat, and the low price at which land can now be pur- ased, and the ease with which it can be tilled, make wheat-growing e of the most profitable of pursuits. The present year, where farms e large, say 2,000 acres, well conducted and situated convenient to ter transportation, the average yield was 20 bushels to the acre, sold r about $1 50 per bushel, realizing $30 to an acre, at a cost of produc- n of about $10, leaving a clear profit of $20 per acre. Such a farm ould then make a clear profit of $40,000. This would be sufficient to ke up another equally large piece of land, break it, stock it, and fence thus showing a profit of 100 per centum a year on the original invest- ent.

Under such stimulus as this affords, it is easy to see how rapid must the expansion of the area of land cultivated for producing wheat.

It is estimated that there are now 2,000,000 acres of land under culti- tion in Minnesota, and that of wheat alone there is this year a pro- ct of 20,000,000 bushels. It is also estimated that this is only about per cent. of the capacity of the State when it shall all come under cul- vation. If so, the future crop may reach 400,000,000 bushels in this te alone, amounting to 12,000,000 tons; of this two-thirds would not needed by the population of the State, so that there would be of this icle alone 8,000,000 tons for transportation.

At the present time it is estimated that in the States of Wisconsin, nois, Iowa, and Minnesota there is 70,000,000 bushels of wheat for nsportation eastward, within the limits of the Mississippi valley trib- ry to the water lines of transportation, the improvement of which is der my charge, (viz: the Mississippi and tributaries above Rock and Rapids,) and one-half of which would, were the Wisconsin and x river line as good now as it is susceptible of being made, pass over t line in preference to any other; that is, about 35,000,000 bush- or 1,050,000 tons. The present charges for transporting this from Mississippi river to Lake Michigan, by railroad, is about $5 per ton, king the cost of moving this half of the crop from the Mississippi to lakes, not including river transportation, $5,250,000. It is believed t the railroad transportation would be profitable at $3 30 per ton.

We have arrived at this by allowing two cents per ton per mile, and averaging the length of the following roads:

	Miles.
Fulton and Chicago	136
Racine and Savanna	142
Dunleith and Chicago	189
Prairie du Chien and Milwaukee	194
La Crosse and Milwaukee	195
Hudson and Bayfield	150
St. Paul and Superior	150

The competition of an independent canal and river line would then bring the railroads down at least to this price, and make the price of moving half of this year's crop $3,675,000, thus effecting a saving to the producers and consumers of $1,785,000.

If the red line, as it is called, from New York to Chicago should effect an extension to the Mississippi, and carry freights at the rates they now do, which is about $1\frac{7}{10}$ per ton per mile, it would not reduce the price in Minnesota, for connections can only be made by way of Chicago, and the increase of distance would make, at even these low rates, a higher average cost of reaching the lake from the Mississippi. Even those points on the Mississippi nearest Chicago, like Rock Island, Savanna, and Dunleith, would, by the red line, lose all the benefits to be derived from the water transportation from Lake Michigan east, since the grain, once in these cars, would have to go on them all the way to the seaboard at the same rates.

We believe it safe to say that a good line of water transportation from the Mississippi to Green Bay can be built so as to profitably transport wheat at one-half cent per ton per mile. The line would be 280 miles long, and this would make the cost $1 40 per ton, a saving of $1 90 per ton over the cheapest practicable railroad transportation. This, in the present wheat crop, would save over what the railroads charge $3 60 per ton, making a saving of $3,780,000; or, allowing the railroads to carry as cheap as possible for them to do, the canal would carry $1 90 per ton cheaper, which would save on this year's crop $1,995,000.

It must be kept in view that in these last figures we have supposed one-half the crop to go by railroad, and down the Mississippi below the rapids, and we have not taken into account the benefits of the trade from Lake Michigan to the Mississippi, which will be quite as great an addition. Nor have we more than stated the great future productions of the single State of Minnesota. It is probable that the development will be so rapid in all this wheat-growing region that all the present and proposed railroads, as well as the canals and rivers, will be wanted as fast as they can be built. The stimulus to a full development of the agricultural resources which a return of 100 per cent. per annum gives could not of course be felt to that extent but in favored localities for present transportation.

But where transportation is deficient it is felt mainly in keeping back the prices of lands, so that the profits on investment at points where the wheat on the ground brings $1 per bushel now is not greatly behind that where the price is $1 50. The present profits of the crop to the farmer, paying all that he does in the way of transportation, are very great, so that increasing the production by every stimulus of easy culture and cheap transportation to market will increase the quantity raised, so as to lower the price at the points consumed to certainly one-third below what it is, and thus be a benefit of many millions of dollars annually to the consumers in the eastern States. Perhaps the foregoing

ugh to insure full and thorough consideration of the plans and esti-
I have submitted for improving the Wisconsin river.
ıve now illustrated the benefit of opening the Wisconsin line of
unication independent of the other river transportation. But it is
ent that all the other water lines connected with it must also con-
e to the same end in proportion to their capacity. As a whole,
ıprovements of river transportation and handling can be reduced
vhat they now are quite as much as what I have shown on the rail-
; for wheat to-day is selling at $1 64 in Milwaukee and for but
in St. Paul, a difference of 29 cents per bushel, only 15 cents of
I have given to the railroads. The upper Mississippi river to the
ıt head of navigation is, still more important, as the great trunk
om which the transportation from this region diverges up the Wis-
ı river and down the lower Mississippi river, and into which it flows
he whole valley. Fortunately nature has done so much for it that
ıratively little is needed except at Rock Island and Keokuk rapids,
heir improvement, I will add, though not under my charge, is
l to none in national importance. I have repeated my former
ıtes for improving the Mississippi from Fort Snelling to the Rock
l rapids. The improvement of the navigable branches of the
Mississippi is of public importance in proportion as they contrib-
) the transportation of the great products of the country and the
s necessary to their development. Thus the great lumber produc-
)f Wisconsin and Minnesota is an essential requirement of the
erity of Iowa, Illinois, and Nebraska, and the streams down which
supplies come, the Wisconsin, Black, Chippeway, St. Croix, and
ssippi above the Falls of St. Anthony, all hold a place in providing
e public wants of the Mississippi valley. On all of these the gov-
ent is, besides, largely interested as a landholder. I have, there-
renewed my estimate of last year for the improvement of the Chip-
r and St. Croix rivers, and for a survey of each of them and of the
ssippi above the Falls of St. Anthony—the latter with a view of
ining the cost of dam and lock navigation to its utmost practica-
nit and connecting it with Lake Superior. The only river which it
ns for me to speak of here is the Minnesota. The wheat raised in
alley this year for transportation, from the best information I have,
ut 2,000,000 bushels. Allowing half of this to be brought out by
ilroad, and to cost, on an average, 12 cents a bushel for transport-
to the Mississippi, it will amount to $120,000. The other half will
or river transportation, and if we can get it out for three cents a
l, it will cost but $30,000 to do it, and save $90,000, by the river
ortation, to the producers and consumers. The construction of
neans of passing the little rapids would enable much more of this
to come out by the river, an advantage difficult to measure for a
year, but on the average worth annually the cost of making it,
,000.
in the Minnesota valley that one of the greatest fields for the
ion of wheat-growing is to be found, and in a few years must be
imes more than at present. The money already appropriated will
fice to remove the snags and boulders further up than Mankato,
ı additional appropriation of $20,000 is asked for to complete this
o the mouth of the Yellow Medicine.
e in the original comes in map prepared to accompany the report
K. Warren, major of engineers, &c., showing the relations of the
l lines of transportation under his charge to other lines. Canal
ı blue; railroad lines in red.]

CHAPTER IX.

A summary of the estimates of funds required for the fiscal year ending June 30, 1870.

FOR SURVEYS AND REPORTS PREVIOUSLY ESTIMATED FOR, IN PROGRESS.

1. Completing maps and drawings and report on bridging the Mississippi river between St. Louis, Missouri, and St. Paul, Minnesota	$2,500 00
2. Surveys on the Mississippi river from Winona to Dubuque	30,000 00
3. Surveys on the Mississippi river above the Falls of St. Anthony	10,000 00
4. Surveys on the Chippeway river in Wisconsin	5,000 00
5. Surveys on the St. Croix river of the northwest	5,000 00

FOR IMPROVEMENTS ALREADY BEGUN.

1. Operating two dredge and snag-boats on the Mississippi river, between Fort Snelling and Rock Island rapids	36,000 00
2. For building four barges to attend dredge and snag-boats	4,000 00
3. For experimental dams on the Mississippi river	25,000 00
4. For making a steamboat channel, or lock and dam, at the little falls of the Minnesota river	30,000 00
5. For removing snags and boulders on the Minnesota river, above Mankato	20,000 00

FOR IMPROVEMENTS PREVIOUSLY ESTIMATED FOR, BUT FOR WHICH NO APPROPRIATIONS HAVE BEEN SPECIALLY MADE.

1. For removing snags, &c., from the St. Croix river	5,000 00
2. For protecting the Chippeway river from sliding banks	5,000 00

3. For improving the navigation along the Wisconsin river, from Portage City to its mouth, three plans and estimates:

First plan.—All in river, using wing-dams and Long's scraper; distance, 118 miles; to secure a depth of three feet, low-water navigation, $427,744 37. Improvements to be available the second year; money all wanted the first year; annually thereafter, $30,000.

Second plan.—To secure four feet depth, for navigation at low water; 27 miles in the river; 91 miles of canal, 70 feet wide at bottom, and 80 feet wide at top; 24 miles, being in wider places of old river bed. Locks, 160 by 30 feet; total lock-lift, 138 feet; sides of canal in all cuts paved for use of steamboats, $3,206,790 95. In order to finish in third year, required $1,603,385 45 the first year; the remainder the second year, and $50,000 annually thereafter.

Third plan.—To secure five feet navigation at low water, all to be canal, 118 miles; canal, 70 feet on bottom, 80 feet on top; locks, 160 by 35; total lock-lift, 175 feet; sides of canal in cuts paved to allow the use of steamboats, $4,164,270. In order to finish in the third year, will require $2,082,135 the first year, and the remainder the second year, and $60,000 annually thereafter.

I would urge the adoption of the third plan if means can be raised, providing, however, at first, for only a four foot navigation, which, for a continuous canal, would cost $397,500 less than that given in the third plan. The second plan, if adopted, should be carried out with a view to

ɡ changed to the third, if ever required. The first plan, three feet ɡation, may have too much inconvenience for the great transporta- destined for this route.

PERSONAL.

e amount of labor which the works under my charge have required ɔnly be appreciated by considering the hundreds of miles of rivers which it extends. We have now got these rivers all mapped, so we have in the office accurate information and surveys of the most rtant localities, and at least a general knowledge of the whole. e has been much difficulty in getting assistants of the right kind ıch work, and it has been found too arduous for some possessed of desired ability. Mr. C. H. Conwell, a graduate from Cambridge, became very proficient in the requirements of my work, but his :itution was enfeebled, and, greatly to my regret, he has had to stop. e of our most important assistants, the engineer in charge of the line of levels of the Wisconsin survey, Mr. J. Z. Osburne, took sick lied of a fever, when that work was nearly completed, in the field. ıch of the work has been, without regard to hours, carried on to the imit of endurance, yet we have, in hardly one case, met the urgent ınds of the interests we have been working for.

r my shortcomings in making returns and accounts to the engineer quarters, I feel grateful for having had extended to me the fullest arance, and thankful for the promptness with which all my requisi- and requests have been granted.

Very respectfully, your obedient servant,

G. K. WARREN,
Brevet Major General and Major of Engineers.

G 1.

rey and improvement of the upper Mississippi river and tributaries.

UNITED STATES ENGINEER OFFICE,
April 6, 1868.

NERAL: I beg leave to submit the following report, making some ɡes in my former estimate sent to you last September, and giving additional ones not prepared at the time the others were rendered. e estimates now forwarded are, I believe, in accordance with the ıtion of Congress of March 18, 1868, which requires the estimates nds for the fiscal year ending June 30, 1869, to be reduced "as far ıy be safely and prudently done, having in view the protection of from injury or deterioration, and reasonable progress towards com- ıg the same, regard being had to the wants of commerce in each

this report I will give:

A statement of the appropriation under which I am working, their nts, and the amonnts expended and on hand March 31, 1868.

A brief account of each of the works under these appropriations.

The recommendations I have to make in regard to further appro- ons for these works; and

Introduce those additional public works to which my attention has drawn by resolutions of legislative or municipal bodies. My com- reports will have to be deferred till more time can be given to :nt them properly.

1. *Appropriations available during the fiscal year ending June* 30, 1868, *and amounts expended and on hand March* 31, 1868.

I am conducting operations the present fiscal year under the following named appropriations made by act of Congress approved March 2, 1867:

1. For building and operating two dredges and snag-boats to be used on the Mississippi river between Fort Snelling and Rock Island rapids, $96,000.

2. For building and operating one dredge and snag-boat on the Wisconsin river, $40,000.

3. For removing snags and boulders throughout the Minnesota river, $37,500.

4. "For examination and surveys of works of improvement for which appropriations have been heretofore made, and concerning which no sufficient information is now in possession of the department, (War Department,) and for examination and survey at other points in the fourth and fifth sections of this act specified; that is to say * * * on the western and northwestern rivers, $125,000.

SEC. 5. *And be it further enacted*, That the Secretary of War is hereby directed to cause a continuance of examinations or surveys, or both, at the following points, namely: Of the Mississippi river, above the Falls of St. Anthony, and between the Falls of St. Anthony and Rock Island rapids, and of the Wisconsin river. * * * " The points thus specified in section 5 were those for which special estimates were made by me, and submitted, approved by the Chief of Engineers, January 29, 1867. (H. Ex. Doc. No. 58, 2d sess. 39th Cong.)

The estimates for additional survey are, for the Mississippi, above the Falls of St. Anthony	$7,500 00
The Mississippi, between the Falls of St. Anthony and Rock Island rapids	35,000 00
The Wisconsin river	7,500 00
Total	50,000 00

There were also additional survey and examinations needed to complete the work already assigned to and begun by me, under section 4 of the similar appropriation act of the 39th Congress at its first session, approved June 23, 1866, which specified, "For examining and reporting upon the subject of constructing railroad bridges across the Mississippi river between St. Paul, in Minnesota, and St. Louis, in the State of Missouri, upon such plans of construction as will offer the least impediment to navigation of the river;" for the preceding year had not allowed sufficient time to finish so important a work, and the river up to that time had presented but the single phase of low water.

After the passage of the act approved March 2, 1867, in the form already quoted which designates no exact sums for making surveys and examinations of the rivers upon which I was engaged, I applied to the Chief of Engineers for information as to the amount that could be allowed to me, and I quote the following, which was received in reply, dated May 16, 1867:

The appropriation of $125,000 made by the act approved March 2, 1867, was intended to include the sums required for all the surveys and examinations of the western and northwestern rivers, provided for in the 5th section of the act, as far as it would extend, and as there are other surveys of great importance to be provided for, this department does not feel justified in allotting more than $40,000 to those under your [my] charge. If it is possible, however, to grant you the additional sum required by your estimate, you [I] will be advised of it.

It must be obvious to all those interested in the works under my charge that the allowance under the circumstances was fully as much as could have been expected. Subsequently $2,500 more was allotted.

The following tabular statement exhibits the amount appropriated or assigned to work under my supervision, the amounts expended and the balance on hand March 31, 1868, the end of the first quarter of 1868:

Appropriation made at 2d session 39th Congress.	Appropriation for examination and survey of western and northwestern rivers.	Appropriation for dredges and snag-boats on the Mississippi river.	Appropriation for dredges and snag-boats on the Wisconsin river.	Appropriation for removing snags and boulders in Minnesota river.
Amount appropriated..	$42,500 00	$96,000 00	$40,000 00	$37,500 00
Amount expended.....	39,813 97	75,818 61	2,316 96	18,171 34
Amount unexpended ..	2,686 03	20,181 39	37,684 04	19,328 66

2. *Nature of the different works and of the expenditures and estimates of the smallest amount we should be restricted to in the coming season, with due regard to the works in hand and to the public interests involved.*

SURVEYS.

The long period of high water in the summer of 1867, on the upper Mississippi, caused me to give over the examination of the Mississippi above the Falls of St. Anthony, as proposed in my report, and nothing more was done than to collect information, as far as practicable, so that it might be attended to in the best manner at some future time. Besides the unfavorable season, there was not so much money appropriated as estimated for by about the amount estimated for this object. So my surveys were confined to the Mississippi below the falls and to the Wisconsin river and Minnesota river.

SURVEYS ON THE WISCONSIN RIVER.

Notwithstanding the high water on the Mississippi river, the rains did not reach the valley of the Wisconsin, which remained unusually low and gave most favorable opportunity for surveys, and a thorough survey from Portage to the mouth was made. The maps are now in an advanced state, on a scale of 400 feet to an inch, and will give ample details of the nature of the bed, banks, obstructions, depths of water, &c., &c. The distance from Portage to the mouth of the river is 118 miles, and the descent at low water 169 feet. The volume of the river is, at its lowest stage, according to measurement, 3,000 cubic feet per second.

The cost of the survey exceeded my estimate and approximated to that of Major Suter's, viz: $15,000. It was conducted as economically as it is practicable to organize and prosecute surveys with new parties; but there are not less than three lines to be run on such rivers as the Wisconsin and upper Mississippi, where one line would answer upon the Ohio, owing to the great multiplicity of islands in the former.

SURVEYS ON THE MISSISSIPPI RIVER.

These were conducted over all the shoal places where we had surveyed them in 1866, so that we might compare the changes made by this year's floods. The changes were important and very instructive to us in planning improvements and works upon the river. The surveys

were, besides, made continuous over all the troublesome shoals from the Falls of St. Anthony to Winona, and a survey was also made of Coon slough and Raft channel of the Guttenburg and Cassville shoals, and at some minor points of interest. An extended series of discharge and velocity measurements were made at St. Paul and vicinity, and river gauges were observed on all the rivers under survey and improvement.

SURVEYS ON THE MINNESOTA RIVER.

On the Minnesota an examination was made from its mouth to the head of Big Stone lake, so as to gain information of the effects of the summer floods and to extend the map of the river above the mouth of the Yellowstone, which is as far up as the examination had been conducted in 1866.

SURVEYING OUTFIT.

This consists now of two large flat-boats fitted up for quarters for surveying parties, and about 25 small row-boats and skiffs, the whole being perishable material, and having cost the appropriation about $7,000. These will answer to prosecute the surveys on the Mississippi and its tributaries, if they are continued till all important surveys are finished; and there will be, in addition, required for the Mississippi above the rapids, a small steam propeller, costing about $3,000 dollars.

ADDITIONAL SURVEYS REQUIRED.

It is believed that no further surveys will be required on the Minnesota and Wisconsin rivers, except it may be in some limited spaces, to supply information on some point whose importance became known by the survey already made, and not known before.

There is a necessity for completing the survey of the Mississippi so as to make a continuous map of it from the Falls of St. Anthony to Rock Island rapids, and it is best to occupy two years in doing it, because part of it will admit of this delay, and in the end it will be more economical, as better enabling us to use up and wear out our outfit and not require an increase of our present one. There should not be less than $30,000 for this Mississippi survey in the coming year, and for finishing the maps afterward. The examination and survey of the Mississippi above the falls will require $7,000.

There is also a memorial before Congress in relation to rivers and harbors under my supervision that requires a survey of the Chippewa river, of the St. Croix river, and of the harbor at Alton. I think there will be required for the Chippewa river $10,000; for the St. Croix, $5,000, and for Alton harbor $5,000.

There are also some additional measurements required to complete the collection of material on the subject of bridging the Mississippi between St. Paul and St. Louis, and completing the maps and diagrams illustrating it, if so, requiring $6,000. There is an absolute necessity for this, in order to complete this important subject and present it to Congress. This matter has greatly increased in magnitude since the passage of the general law in relation to bridging the Mississippi, and these bridges may be a fruitful source of litigation and trouble hereafter, requiring the amplest information to settle.

I will recapitulate the different items required for additional surveys, naming them in the order in which I deem them to be of public importance.

he estimate for surveys in my former report was but $50,000, but in
ie last three items were omitted.
; should be considered, in judging of the importance of these surveys,
; these northwestern rivers have not been surveyed and mapped before,
; on all of them public works of improvement are needed and solicited
he people, and that no engineer nor legislative body can properly
sider the necessity for improvement, nor the means required to effect
ll the survey and maps are made. It is only by surveys that an
ineer can assemble the facts, subject them to analysis, and compre-
d the physical laws governing the stream it is proposed to operate
n. Good maps and profiles and measurements have the further
antage, that every other engineer can, from them, readily prepare
1 plans as his own experience may suggest, or test the soundness of
se submited to him. These things, when properly done, require much
e; and even if the works of improvement should, from necessity, be
pended, the surveys should, by all means, be kept going on, so that
n the improvement is again resumed, full knowledge will be at hand
uide it. Besides the injury to the material on hand by suspending
surveys, there will be lost the valuable experience acquired by the
stants, by their having to seek a livelihood in other fields. The special
uirements for a proper river surveyor are not generally met in the
inary engineering experience. Nothing shows the necessity of these
reys more than the fact that we are unable yet to submit our definite
ns in many cases because the maps of the surveys are still incomplete,
much of that failure that may be seen to have attended former river
rovements arise solely from imperfect preparatory surveys, and a
sequent attempt to improve where there was no knowledge of the
ses producing the abstraction and the means of counteracting them.

IMPROVEMENT OF THE MISSISSIPPI.

f the appropriation of $96,000 for two dredges and snag-boats, and
rating them one year, there remains the two boats purchased and
,181 39 unexpended. This money will be needed before the end of
present fiscal year to complete the repairs, changes and outfit for
ring and wrecking which these boats require and they will then

desperate want of means should compel them to tie up. Letters from the principal steamboat men navigating the upper Mississippi testify to the great benefit the dredging, or, more properly, the scraping, produced on the bars; and the result of the last year's work convinces me that these boats can be relied upon to increase the depth over the sand-bars from eight to twelve inches in low stages, which it is safe to say nearly doubles the carrying capacity of the boats now in use. The sand-bars have the shoalest part at the lowest edge deepen suddenly below this, and very gently above, so that an increased depth of one foot will be found within 150 to 200 feet above the lower edge. I believe, however, that this is as great an alleviation as can be relied upon from such source without a disproportionate expense, and in some localities such complications exist in the sand-bars that it will probably be necessary to resort to wing-dams or jettees, so as, if, not to prevent the obstruction forming below, at least to reduce it to a more simple form. Such a case, Frenchman's bar, below St. Paul, presented last year. There are cases, too, where the river becomes divided into several channels, none of which affords the same depth as where the river is united, and it is then desirable to close up all but one. Such a case exists above Nininger. There are, also, cases where small but deep and favorable low-water channels exist which escape the sand moved at high water and deposited into the main channel, and which need protection at low water from the sand brought into it from the main channel through connecting passages, and also the prevention of the escape of water from them. Such a case is presented at Beef slough. There are also a variety of other cases that could be enumerated and many that cannot be foreseen, but which must be remedied as they occur. It will be necessary, too, in some places, to protect the banks and islands from abrasure.

In all these cases I would use stone and trees and brush; the stone furnishing the weight to hold the dam in place, and the trees and brush the bond to keep it together as one mass and prevent its being removed piecemeal. This combination is also well adapted to collects and on and around it, and thus increase its stability and effect. I think it was the absence of a suitable bond like the wood affords that rendered the dams formerly placed on the sandy portions of the Ohio (independent of any defect of location) so unstable; besides, as a reason for not applying the Ohio experience to the upper Mississippi, there is the great difference in their high-water velocities, which are so much the greater on the Ohio. The proper method of applying these dams on the upper Mississippi depends upon the peculiarity of the river. Its waters are clear, and there is no mud or sediment deposited from it, in the ordinary sense of the word. The beds and bottom are nearly all sand; the bottom lands are overflowed many feet, and their height is just that to which the current will raise the sand as it passes over the bed, and is the same as the tops of the highest bars, which differ from islands and bottoms only in not having been formed long enough to have produced a growth of trees. The sand is very heavy, composed mainly of silicas, with some iron. When stirred up it sinks again very rapidly. It is moved along mainly at high water and drops again as soon as the current slackens, so that at low water comparatively little sand is in motion. I am having very careful measurements in progress to determine better than we now know the nature of the sand, which in different years presents such a variety of phases. It seems certain that all improvements will have to be made to meet occasions for these yearly as they arise; and besides the dredge-boats we now have, we must have at properly chosen localities large collections of stone ready for use, and barges, when used in

ıad by far the best channel on the side that in 1866 it was thought close up. A provision should be made in the law authorizing gineer to close such channels as he thinks best for the public good, he will not be stopped by injunctions and difficulties certain to ıs they did the past year in the attempt of the Chippewa River ement Company, organized under the laws of Wisconsin, to close Beef slough. I feel prepared now to give this subject of closing ng channels a more extended trial than I did on completing my report, and wish to have my powers defined in attempting to ın such work.

IMPROVEMENT OF THE WISCONSIN RIVER.

improvement is intended to form part of a line of communication ts from all places on the upper Mississippi and tributaries by way Wisconsin river, upper Fox river, Lake Winnebago, and lower ver to Green bay, and there connect with the water transportation h the lakes eastward. During the past season the Brooklyn, a oat of considerable capacity, came through from Green bay to St. vith a large freight, and returned. But the general navigation of eam has of late years been nearly suspended for several reasons. complete condition of the canal improvements on the Fox river me of these, and it does not seem advisable for the company to ıte these improvements more rapidly than it is now doing until ing is done to secure them the improved navigation of the Wis- river. Besides the foregoing reason for the absence of navigation ıe river, is the effect of the Milwaukee and Prairie du Chien rail- hich draws most of the local business of the valley to itself. But, ıstanding this, steamboats would continue to run upon the river not for the three railroads and three common road bridges crossing een Portage and the mouth. These bridges have draws, but the re so badly located and constructed as to greatly endanger the of boats, and to cause them ruinous delays.

having been no prospect of vessels navigating the river during t season, and the appropriation of $40,000 being for procuring and ıg a dredge and snag-boat whose service would not in such case be

water volume 3,100 cubic feet per second, the range from low to high water nine to ten feet. A great portion of the river bed and bottom lands is sand, the same as I have already described on the Mississippi. The obstructions are in almost every particular the same, and I am inclined to adopt the same method of improvement. But as the Wisconsin is smaller than the Mississippi at St. Paul, in the proportion of three to five at low water, I expect that to secure the same depth of water as on the Mississippi will require a greater expenditure. From the present state of our investigations, therefore, I am in favor of dams, jettees, revetments, &c., of brush and stone, in connection with dredging, in preference to a canal along the banks or to locks and dams in the river, though the estimates have not yet been completed. The question as to kind of improvement will mainly turn upon the making of six and seven feet navigation; but with three and four at the lowest stages, and boats properly constructed and with a wide passage-way, almost any amount of transportation can be done.

I have thought that from $20,000 to $30,000 per mile would secure this low-water navigation from three to four feet depth of water. The distance being 118 miles, this would require a total of from $2,360,000 to $3,540,000 for the entire river. An expense annually would afterwards be required for repair, amounting to from $20,000 to $30,000.

It will be necessary to thoroughly remodel all the bridges across the river where the draws are placed, and inasmuch as they have been placed as they are without opposition, it may be but just, in reconstructing them, that the river improvement should bear a portion of the expense, as has been provided for in the case of Rock Island bridge.

The way to carry on such an improvement as I have in view is to follow as much as possible the course proved by experience. As much experience is yet to be acquired, I would, as a preliminary work, recommend an appropriation of $50,000 in addition to the amount now available, to be used in driving piles above all the draw-bridges at the draws, to facilitate the passage of boats before the bridges are reconstructed, in cutting down from the banks the numerous trees now hanging over the channel-way where boats must pass, and make such dams as may be required at some of the worst places, and thus test this method of improvement more fully than has yet been done. If a canal of great size is required between the Mississippi and the lakes, there is no question but that of cost involved in its construction here. It is a very favorable feature that the Wisconsin river, at low stage, is nearly on a level with the summit of the canal at Portage, and no expensive works are required to procure from this river all the water that might be needed for lockage thence to Winnebago lake. As a canal route, the natural feeders are inexhaustible. The descent from the summit at Portage to Lake Michigan is 210 feet, and not 315 feet, as stated by mistake in General Wilson's report. The lockage on this line of improvement would be nearly the same as on the Illinois one; but it is unnecessary to make comparisons between these two lines. Commercially they are wanted independent of each other, and one could not, if built, do away with the necessity for the other.

IMPROVEMENT OF THE MINNESOTA RIVER.

Of the appropriation of $37,500 for removing snags and boulders, $19,328 66 remains unexpended. The expenditures have been mainly for removing snags from the channel and cutting down trees impending from the banks. There proves to be more snags needing to be removed than was at first estimated for, and a further appropriation will be

s work, in accordance with the resolution of Congress quoted
ning of this report, be so made as to leave the manner of its
to be determined by the engineer hereafter, and that, if any
und, it may be expended in the removal of snags above the

NT OF THE MISSISSIPPI RIVER BETWEEN FORT SNELLING AND FALLS OF ST. ANTHONY.

ate for a dam and lock with lift of 13 feet at Meeker's island
n my last report. Since then our further surveys make it
another such dam and lock would be required near the
e Minnehaha creek. Each of these dams, with locks, would
235,000. The importance of this work is fully set forth in
l of the Minnesota legislature to Congress, presented with
1 January, 1865.

ose improvement has been petitioned for by legislatures, &c., &c:

IMPROVEMENT OF THE ST. CROIX RIVER.

en furnished with a copy of a memorial to Congress, from
re of Minnesota, which asks for an appropriation for improv-
eam. The improvement required is the removal of snags,
m, piers, &c., that now obstruct this river, and I think $5,000
antageously expended in giving immediate relief from these.
say how much benefit can be secured to this river by a
stem of improvement until a survey is made, and for doing
made an estimate of $5,000.

IMPROVEMENT OF THE CHIPPEWA RIVER.

has also been memorialized to aid in the improvement of this
ve made considerable examination of it in studying its rela-
Mississippi, which it closely resembles in many of its features.
rush dams are as applicable to it as to any river I have seen.
submit a thorough plan of them until a survey is made for

ALTON HARBOR, ILLINOIS.

A report concerning the filling up of this harbor with sand was made to me by my assistant, Major H. C. Long, United States civil engineers, based on a preliminary survey made at the expense of the city. He estimates that $100,000 would be required to remove the difficulty. We are unable to enter into the consideration of all the questions here involved, where the union of the Missouri with the Mississippi may perform an important part in producing the condition now existing, and a further and elaborate survey is necessary, for which I have made an estimate of $5,000. It would seem perfectly safe to make the appropriation estimated for, leaving the method of its application to be determined by the engineer as soon as the results of the surveys are made up. The report of Major Long will be submitted hereafter. The full reports of several of the other works are nearly complete, but it is not thought possible to take time to prepare them for submitting with this report.

RECAPITULATION OF ESTIMATES.

For completing report, maps and diagrams on bridges on Mississippi river	$6,000
1. For survey on Mississippi river, from Falls of St. Anthony to Rock Island rapids	30,000
2. For survey on upper Mississippi, above the falls	10,000
3. For survey on Chippewa river	10,000
4. For survey on St. Croix river	5,000
5. For survey of Alton harbor and vicinity	5,000
6. For operating two dredges and snag-boats one year	36,000
7. For wing-dams and other dams on Mississippi river	25,000
8. For improvement of Little Falls on Minnesota river	30,000
9. For dams and removal of obstructions on Wisconsin river	50,000
10. For protecting Chippewa river from sliding banks	5,000
11. For removing obstructions in the St. Croix river	5,000
12. For dam and lock at Meeker's island	235,000
13. For dams at Alton harbor, Illinois	100,000

Items 3, 4, 5, 9, 10, 11 and 13 are introduced here for the first time. Item No. 7 is a former one increased from $10,000. Item No. 12 was introduced in my former report, but not acted upon by Congress.

Respectfully submitted.

G. K. WARREN,
Brevet Major General U. S. A., and Major of Engineers.

Brevet Major General A. A. HUMPHREYS, U. S. A.,
Brigadier General and Chief of Engineers.

G 2.

WASHINGTON, D. C., *April* 9, 1868.

GENERAL: I have the honor to forward herewith the report of United States Civil Engineer H. C. Long, concerning the present condition and requirements of the harbor of Alton, Illinois.

This harbor is on the Mississippi river, just above where it is joined by the Missouri river, and the influence of both rivers is probably concerned in producing the unfavorable condition of the harbor now existing. At low water boats are prevented by a dry sand-bar from landing

e exact plan to adopt to remedy the existing evils, and reserves
it to somewhat modify his recommendations, if these surveys
all for a modification of them.
the reservations made by him, I submit his report with my
l, and express also my satisfaction with the prompt manner he
ied out my directions, and my belief that he has presented the
is completely as the circumstances admit.
eport was made by him in obedience to my instructions, which
en on authority of the chief of engineers, to whom I had sub-
he application of the Board of Trade of the city of Alton to
h examination and report made.
ours respectfully,

G. K. WARREN,
Bvt. Major Gen'l U. S. A., Major of Engineers.

t Major General A. A. HUMPHREYS,
Brigadier General and Chief of Engineers.

ALTON, ILLINOIS, *March* 15, 1868.

RAL: I herewith submit a brief report of examinations at Alton
and the conclusions arrived at.
were undertaken in accordance with your instruction, of Feb-
1868, a copy of which is as follows, viz:

HEADQUARTERS UNITED STATES ENGINEER OFFICE,
Saint Paul, Minnesota, February 1, 1868.

e following are your instructions:
will proceed from here to Alton, Illinois, and make such examination of that
vicinity as you can at this season. The object will be to report to me the wants
navigation as complained of, and their supposed cause, the proposed remedy and
effecting same. Should you be unable to do this without making additional
u will so report, and present an estimate of the expense, and the time when they
made. You will consult freely with such citizens of Alton as can aid you in
.
will also proceed to St. Louis to inquire into the cost and facility of making such
for and alterations in the boats we have as you think will probably be required
coming season.
understood that these duties are not to prevent your exercising all necessary
over the party at work on the Mississippi under Mr. D. S. Stombs, that may be

veys, I availed myself of the liberality of the city council of Alton, who appropriated, at my suggestion, $250 for this purpose.

This amount was of course too small for the prosecution of any extended surveys, but was deemed sufficient for measuring the existing sand-bars, making a few triangulations across the Mississippi to determine its width, general location, and extent of islands, tow-heads, slough, &c., &c., and their relative positions with reference to the city and harbor of Alton.

Besides, I wished to save time, in laying this report before yourself and the proper authorities at Washington, and improve the favorable opportunity presented for examining into the condition of the river affecting Alton harbor, afforded by a low stage of water which prevailed at the time of my arrival.

These preliminary surveys were made by Messrs. Swift and Long, city engineers. The result is the accompanying sketch or chart, which, for convenience of reference, has been platted on a scale of 4,000 feet to the inch, giving the appearance of the Mississippi river and harbor of Alton at the period referred to in this report, viz: February 5, 1868, to March 5, 1868. See drawing No. 1.

As your instructions have defined my duties with admirable perspicuity, I shall treat the subject in the order therein set forth, viz:

FIRST.—"*The wants of the river navigation, as complained of, and their supposed cause.*"

Very serious apprehensions are entertained by persons competent to give an opinion in such matters, who have watched the operations of the Mississippi in the vicinity of Alton for several years past, that, at any of the annual floods, such changes in the current and general course of the river may take place as to entirely prevent steamboats from approaching the landing during ordinary and low-water stages, at least two-thirds of the year, thus greatly injuring the commerce and consequent prosperity of the city.

SECOND.—"*The supposed cause of the evil.*"

At Alton, the Mississippi river is bounded by high limestone bluffs on the Illinois side, approaching the river margin at the upper landing, and extending northerly 20 miles to the mouth of the Illinois. While, below the city, the bluffs, receding from the river an average distance of five or six miles, run nearly parallel to its general course to the mouth of Kaskaskia, embracing an area of about 360 square miles of land of wonderful fertility, well known as the "Great American Bottom."

The general direction of these bluffs is as well represented on the sketch as its limits will permit.

On the Missouri side, the natural surface is but little, if any, above high water mark, and all that tract of land situated between the Mississippi and Missouri rivers, comprising the easterly part of St. Charles county, is subject to overflow during excessive floods.

The dry bar "A A" is about 5,000 feet long by 1,500 feet in width, and nearly overlaps the head of the island below. It has been gradually working down stream, and it is feared that a connection will be formed with the island, and the water making its way behind both, the main body of the river and low-water channel will be permanently changed to the Missouri shore, the bar forced over towards Alton, and the city absolutely blockaded.

At the time of my examination (the river then being about three feet above ordinary low stages) there was more water passing down the slough, D D, than on the Alton side of the island. There was a depth of 12 feet entirely through the former, with ample width for the passage of the largest sized steamers; while there was but six or seven feet through the latter, and in places the channel was quite narrow, inconveniently and dangerously so, should large boats attempt to pass each other at the contracted points.

There is no natural obstacle on the Missouri side which will prevent the Mississippi river from making a wide and permanent passage-way in the direction apprehended, should it at the next or any subsequent rise force its way around the head of the bar A A and along the slough D D.

This Missouri shore is composed of the same light sandy alluvium, through which the Missouri river is constantly shifting and changing its outlet; at one time working up, at another down the Mississippi, in the most capricious and unaccountable manner.

Since 1852, the mouth of the Missouri has been working its way down stream, and is now at least one mile below where it was at the date mentioned. Whether it will now remain stationary or again alter its position, it is impossible to predicate, and can only be known by observation; for, as before intimated, there is nothing in the nature of the soil at its mouth which can in any degree control its impulses, or make permanent its point of junction with the Mississippi.

By a further reference to the sketch it will be seen that the main channel of the Mississippi river (shown by dotted black lines) leaves the rocky shore on the Illinois side near a point marked Hop Hollow, and crosses diagonally to the opposite side, then returns again to the Illinois side near "Lorks Upper Lime-kiln," and is again thrown back towards the bar. The river can make no impression on the rock, but is constantly being deflected to the Missouri shore, where there is nothing but light sand to oppose its progress; and as I understand the explanation of the pilots and river experts who have watched its operations for many years past, the channel is constantly abrading the Missouri shore and increasing its tendency to force a passage in that direction and around the head of the bar and along the chute, or slough, as explained in a foregoing paragraph.

A growth of young cottonwoods, grass, and willows is springing up near the center of the bar A A shown on the sketch, and a lodgment of drift-wood taking place, indicating unmistakably the permanent form that the bar is assuming and the probability that in time it will become an island.

The dry bar B B, below the city, has been extending upward and outward for several years past; at its greatest width, at the time of my examinations, February 5 to March 5, there was a water space of only 800 feet between the bar and Ellis's island, with a depth of seven feet scant in the channel, the latter being not over 250 or 300 feet in width.

In the last five or six years there has been an accumulation of sand on this bar averaging three and a half feet in depth over its entire surface. This is ascertained by measurements, along the railroad track extended across the bar by the Chicago, Alton and St. Louis Railroad Company for the purpose of obtaining ballasting for their road-bed.

This bar (B B) is encroaching rapidly upon the city landing, extending along its front and connecting with the main Illinois shore until it has monopolized three-fourths of the levee, entirely obstructing the low-water harbor for that distance.

A considerable portion of this bar is occasioned by the mud, sand, and city scourings brought down by the Piasa creek, which has its outlet through an arched culvert at H. This culvert also serves the purpose of a main sewer to Alton, extending through one of the principal streets of the city for a distance of 4,000 feet.

The bar now under consideration (B B) acts as a dam to a very considerable degree, and, by partially checking the flow of water, and backing it, assists the current deflected from the rocky shore at Hop Hollow and the upper lime-kilns, in forcing a large portion of the river on each side of the tow-head E, and through the sluices F F.

The depth of water in these two sluices was found to be 12 feet, with a width of 250 feet in the upper and 350 feet in the lower one, with a strong current, and constant abrasion of the head of the island and tow-head. In fact, at the time of observation, the main body of water in the slough D D was supplied by the sluices F F.

It has been intimated that the projecting points of loose and fragmentary rocks lining the shore above the city landing at C C was a fruitful source of the "evil complained of." These projections are doubtless very injurious. It will be observed that the river narrows considerably at this locality. The evil will grow worse from year to year. Their further accumulation should be strictly prohibited by city ordinance. I have endeavored to impress the importance and necessity of attending to this matter upon the city authorities of Alton.

The rock thus wasted will be serviceable and convenient for building dikes or wing-dams. If contracts are made for this purpose, it should be one of the stipulations that the contractor take away and use this material.

I have thus endeavored to describe the peculiarities of the river in the vicinity of the "evil complained of."

They may be stated more succinctly and in general terms as follows, viz:

A rock-bound shore on the Illinois side on which the river can make no impression; a light alluvium on the Missouri side, which offers but little resistance to its encroachments; some artificial obstructions as at the mouth of Piasa creek; the heaps of refuse stone and *con* from the lime-kilns above the city, and a natural tendency of the river to make towards the points of least resistance.

THIRD.—"*The proposed remedy*"

Is a stone dike across the head of the slough, near the upper end of Ellis's island, (the situation of the proposed dike is shown on the sketch,) and a wing-dam or breakwater at the head of the dry bar A A. The exact location of this work to be determined by the United States engineer at the time of constructing them, and also the height to which it is necessary to raise them.

It is believed that the combined action of these structures, by throwing the river over onto and along the Illinois shore, will give a sufficient depth of water at all seasons of the year, and wash away the sand-bar B B below the city, and, from the strong and direct current thus produced, have a tendency to modify the extensive abrasions going on opposite the mouth of the Missouri.

At locality last mentioned the Mississippi, reinforced by the strong current of the Missouri, is rapidly encroaching on the American bottom, and working its way into a succession of lakes and bayous, old beds of the river, to such an extent that fears are entertained that the river

gain pursue its course along the Illinois bluffs, and forsake its
t channel in front of St. Louis.
eys recently made under the direction of the city engineer of St.
show that there has been an abrasion of 3,500 feet opposite the
of the Missouri since 1862.
leave to refer you to the very interesting remarks of Major George
g on this subject, giving also his view of the causes of the diffi-
Alton. Major Long graduated at West Point in 1824. Theoret-
ıd practically an engineer, and one of the earliest inhabitants of
ıe has been acquainted with the characteristics and operations
lississippi from the Balize to Fort Snelling for nearly 40 years.
ıions in this matter are entitled to the greatest respect. (See
ɪ A.)
sing the chute or slough at the head of Ellis's island, a basin
t wide, 2 miles long, 10 feet deep at lowest stages, will be formed,
; a convenient and safe harbor for steamboats and other craft
he winter. This slough has been used for such purposes by
the principal St. Louis lines of steamboats for several years.
will insure its preservation, and in this alone be of great benefit
neral commerce of the Mississippi.
l the main body of the river take that course, the slough will no
: desirable or safe, as the drift and ice will follow the main

ot prepared to give an opinion as to the exact location of the
ı until more extended surveys, accompanied by current and
)bservations, shall have been made; on which also depend the
ation of its length and direction.

—"*The cost of effecting the latter;*" *that is, the cost of proposed remedy, &c., with plan and estimates.*

e sake of economy, to secure a good foundation, and prevent
the spreading out and loss of stone in the shifting and light
prising the bottom of the slough, it is proposed to make caissons
timber three or four feet wider than the base of the stone-work,
them across the slough in the required direction; these found-
be composed of trunks of trees and rough logs, an abundance
can be cut on the adjacent shore and island, and hauled or
ıto position, when they can be arranged in rafts. The largest
: two and one-half or three feet apart, the interstices filled with
and branches cut from the trees in trimming them, also brush
ngs, then weighted with stone and sunk to the bottom of the
The first layer to be longitudinal with the line of the dike, the
ansverse, alternating in this way until the surface of low water
l, or four layers of the raft be sunk, forming a caisson upon which
ın stone will be thrown until the dike is raised to the requisite

GENERAL DIMENSIONS OF DIKE.

tions—Timber caissons, filled with brush, stones, &c., &c.—Length,
(about;) width, 60 feet (about;) height, 10 feet (about.)
ructure—Broken stone.—Length, 1,200 feet (about;) area of
20 square feet (about.)

ESTIMATED COST OF DIKE.

Timber, and labor in cutting same, hauling to river, &c., constructing rafts	$6,500
Stone, &c., for filling interstices and sinking rafts, viz: 6,440 perches, at $2 25	14,490
Contents of main dike above low-water mark, viz: 34,560 perches, at $2 25	77,760
Riprap on head of Ellis's island, to prevent same from washing away, viz: 2,000 perches, at $3	6,000
Superintending, contingencies, &c., &c	7,250
Total	112,000

FIFTH.—"*Cost of additional surveys required, and best time to make them.*"

I do not know of a more interesting field for careful research than the vicinity treated of, or one of more importance to the commerce of the Mississippi valley; involving the solution of questions not only affecting the growth and prosperity of Alton, but of St. Louis.

I can find no maps or records defining with any degree of certainty the present mouth of the Missouri river, the positions of bars, islands, &c., nor am I aware that any careful surveys have been made in this region, since those of Captain R. E. Lee, United States engineer, in 1837, and Captain T. J. Cram, and Lieutenant W. F. Raynolds, topographical engineers, in 1843–4; since which time very great and important changes have taken place.

I therefore recommend that these surveys be made to commence as soon after the annual vernal floods as practicable, and be extended as high as Grafton, mouth of Illinois river, on the Mississippi, and St. Charles, on the Missouri, and below the mouth of the Missouri, embracing the city limits of St. Louis to St. Genevieve on the Missouri side, and mouth of Kaskaskia on the Illinois side.

These surveys, hydrographical and topographical, can be completed the ensuing low-water season, if the weather prove favorable, with all necessary maps, charts, sketches, &c., &c., at a cost not exceeding $10,000. It is contemplated to extend the surveys to the main river bluffs on either shore.

RECAPITULATION OF ESTIMATES.

Construction of stone dike, with foundations of timber, &c., &c., from head of Ellis's island to some point on the Missouri shore	$112,000
Cost of complete surveys from mouth of Illinois river to mouth of Kaskaskia, embracing American bottom, and Missouri river to St. Charles	10,000
Total	122,000

I have thus endeavored to lay before you the results arrived at in carrying out your instructions of February 1. It may reasonably be doubted whether, under the circumstances, we have arrived at the right solution of the cause of the difficulty at Alton; but there can be no question of the magnitude of the "evil," or of the fact that the city is threatened with an entire loss of harbor at all ordinary stages of water.

m not aware that government assistance of this or any other sort
ver been extended to Alton, although, for many reasons arising
her geographical position, she may be entitled to it more than other
of greater pretensions, who claim and receive it.
on lies on the left bank of the Mississippi, about 25 miles above St.
and three miles above the mouth of the Missouri river. It contains
15,000 inhabitants. The importance of the city trade and com-
may be understood by a reference to the report of Messrs. Dobel-
and Frick, the committee appointed by the Board of Trade to pro-
tatistics of the business of Alton for 1867, from which it appears
e business of the city for that period amounted to $12,673,734, and
e revenue collected and paid to the United States during the year
80,000. (See report of committee, Appendix B.)
le reserving to myself the privilege of a more extended treatment
ubject, and perhaps different opinions relative to the causes oper-
) produce the results complained of, after careful and comprehen-
rveys, I have no hesitation, in view of the necessity of some
ned action, in seconding the wishes of the citizens of Alton by
ending the dike at the head of Ellis's island as furnishing speedy
sent relief, sufficient for all practical purposes, and as an experi-
at will be of value as a precedent in settling the many vexed
is relative to works of this character now agitating the public.
itizens of Alton, associated with certain steamboat men and oth-
rested in the navigation of the Mississippi, have already obtained
r from the State of Missouri, under the general statute, regu-
uch matters, whereby the construction of the dike can at once
ed upon. The island and slough are claimed to be within the
f St. Charles county, Missouri.
ecessity and importance of the surveys recommended in this
re most earnestly urged upon your favorable consideration, as the
e method of obtaining correct data on which to base thorough
tematic works of improvement.
ctfully submitted.

HENRY C. LONG,
U. S. Civil Engineer.

t Maj. Gen'l G. K. WARREN, U. S. A.,
Major Corps of Engineers, Superintendent Surveys
and Improvements Upper Mississippi, &c., &c.,

—Since the completion of the surveys alluded to in this report,
5, 1868,) there has been a rise in the Mississippi of several feet,
which the action of the water has been watched with great

an extract from the remarks of Mr. Miller, at a recent meeting
oard of Trade, which goes far to confirm the views advanced in
eding pages, viz:

Minutes of the Board of Trade.

COUNCIL CHAMBER, *Alton, March* 20, 1868.

er, of the committee on river and harbor, made a verbal report, in which he stated
the rise in the river the current was fast washing away the sand-bar A A and
te shore above the city, and if not soon checked would in a short time work its
d the sand-bar, and then through the chute (D D on sketch, page 9) behind Ellis's
hat, in the opinion of Captain Berry, the Missouri shore had been washed away
of 10 rods in width by one mile in length above the sand-bar, and that the sand-
een worn away about three-fourths of a mile, and that the lower end of the bar
proportionately extended down in front of the city; and that it was the duty of the

council to act at once in the matter, to prevent the channel of the river from leaving our shore entirely.

* * * * * * * *

On motion of Mr. Washburn, the following resolution was adopted, viz:

That a committee of four be appointed by the Chair to draw up a memorial and forward the same to the representatives of this district in Congress, calling their attention to the report of Major H. C. Long on our river and harbor surveys, and urging prompt action in securing the required appropriation in the bill for western river improvements.

* * * * * * * *

Above minutes signed by

J. T. DRUMMOND.
Vice President.

J. T. RICE, *Secretary.*

Respectfully submitted.

HENRY C. LONG,
United States Civil Engineer.

[Appendix A, page 375.]

ALTON, *March* 9, 1868.

In the reconnoissance you are about to make of Alton harbor, permit me to bring to your attention the following observations and remarks in relation thereto, viz:

The active cause of the sand-bank that fills the greater portion of the river-bed in front of Alton may be directly traced to the action of the waters of the Missouri at its mouth, or its junction with the Mississippi, during the annual spring freshets. These take place from the last of April to the middle of June, after those of the Mississippi have subsided. The mingling waters of the two rivers above the mouth become slackened, and the sand and alluvium with which they are charged settle to the bottom and thus have filled the channel as above indicated. A still more extensive bank, from a like source and cause, has been formed the Missouri mouth, both of which combined have conduced to below most injurious and damaging results, as I shall proceed to describe.

The bank below the mouth, as it increases during high-water stages of the river, forced the current along the left bank at the fork, wearing it away at a rate that, within my own personal observation, has reached the distance of something like two miles. The most remarkable movement at the mouth in any one year took place about five years since, when near a half a mile of the tongue of land at the junction was suddenly swept away.

This change seemed rapidly to increase the bar between Alton and Ellis's island, which lies about three-fourths the way across from the Illinois to the Missouri shore, in such a manner as to force the greater portion of the water into the slough on the Missouri side of the latter, washing it out into a strong and bold stream, already the main pass for the Mississippi waters at the summer stages of the river.

The draught is now so great into this channel that the line of current at the head of the island takes a northern course for the waters to enter it, and the only barrier to a direct channel from the bend above Alton to reach it is the tenure of a sand-flat athwart its head, which in no long time to come may give way to a further and greater injury to Alton harbor. This slough, which may, even at this time, be considered as the main part of the river in its summer stages, in view of its direction and force, lies in a curve convex to the westward, which has its last course approaching the junction so near that of the Missouri that they join under a very acute angle some two and a half or three miles distant, in

erly direction, from the place of junction prior to the opening of
nnel to its present capacity, and from thence the combined rivers
in the resultant direction of their united forces to be broken
e alluvial soil of the American bottom.
xtent of abrasion into the Illinois shore, as near as I can learn,
niles on the river from Wood river to the town of Madison, at
of Chouteau's island, by a half a mile in depth, or some 1,500
acres of land, which at this time would be valued, at least,
00; and the work is going on with increased rather than a
ed force.
dge which separates the river from Long lake and the *swales*
Wood river and below, to the rear of East St. Louis, now
but some 400 or 500 feet across. When this is carried away, as
will be at no distant period if not prevented by artificial
ıe damage to the farmers, the railroads, and other interests con-
ith the St. Louis trade, would be enormous.
ıter would enter on a level five or six feet above the river at
, which would give a powerful force for damage wherever it
obstructed.
medy to counteract these evils is, first, the erection of a dike
head of Ellis's island to the Missouri shore to direct the
pi water in its direct and proper course below, and to establish
ım or jettee within the mouth of the Missouri, so as to force
ım in the same direction, that the two may unite in the reach
e Missouri's mouth, and thence proceed harmless to their
homes. The Missouri river, I am informed, has still open a
high-water slough along the rocky shore of the right bank,
the track the main stream should be forced into.
works seem thoroughly practicable when we consider the
t interests at stake.
diness with which the shifting sands of these rivers are moved—
s an open channel on one side, and the next year a dry bar in
and the navigable pass on the opposite—indicates the facility
:h they might be managed.
appears to me that there is a pressing and urgent demand for
on in this matter to escape serious consequences and damage
ts above enumerated.
spectfully your obedient servant,

GEORGE W. LONG.

H. C. LONG,
United States Civil Engineer.

[Appendix B, page 397.]

REPORT OF COMMITTEE ON STATISTICS.

sident and members of the Board of Trade of the city of Alton:

EMEN: Your committee, appointed to procure statistics of the
of Alton for the year 1867, beg leave respectfully to report
ing schedule:

and dry goods	$749,000
ieet iron and hardware	947,000
l shoes	600,000

Groceries	$1,472,000
Liquors	256,500
Crockery ware	42,000
Leather	16,000
Drugs and chemicals	564,000
Harness and saddlery	17,000
Insurance	276,734
Woolen goods	150,000
Jewelry	21,000
Tobacco	220,000
Pork	50,000
Founderies and machine shops	487,000
Wagons and carriages	130,000
Wooden ware and cooperage	165,000
Planing and saw mills	100,000
Bricks and stone	559,000
Hides, wool, lard, and tallow	285,000
Banking	16,000,000
Lumber	470,000
Lime and cement	225,000
Brewers	125,000
Flour, wheat, corn, and oats	2,410,000
Boiler making and blacksmithing	75,000
Upholstering and furniture	165,000
Books and stationery	55,000
Marble works	36,000
Ice and gas	5,000
Professional services	50,000
Buildings, 350	350,000
	27,073,234

Thus your committee are able to report that the business of Alton, for the year 1867, amounts to about $12,673,734.

Through the kindness of Mr. W. C. Flagg, collector of this district, we are enabled to verify and correct the statistics obtained by the committee, and also to report that the revenue paid to the United States during the year amounts to at least $180,000

Your committee would respectfully state that they do not assert that the above sum embraces all the amount of business done during the year, but that it is as much as they could obtain reasonable data for.

All of which is respectfully submitted.

JOHN C. DOBELBOWER,
CHARLES H. FRICK,
Committee.

G 3.

WASHINGTON, D. C., *June* 29, 1868.

GENERAL: In obedience to instructions I have examined the location of the railroad bridge across the Ohio river at Steubenville. Mr. W. Milner Roberts, United States civil engineer in charge of improvement of Ohio river, sent a surveying party and an experienced river man, and

companied me himself from Pittsburg to Steubenville. I reached ere on the 22d and completed my observations on the 23d instant.

The several railroad companies forming the line from Pittsburg, Penn-lvania, to Columbus, Ohio, which crosses at this place, consolidated the 1st of May last into one corporation, known as the Pittsburg, olumbus, and St. Louis railroad company. Judge Thomas L. Jewett as elected president. He freely gave me all the information I inquired r, as did also Mr. W. W. Card, the superintendent, and Mr. M. J. ecker, the engineer, all residents of Steubenville.

The company had many difficulties at the outset in establishing the ght of way for this line across the pan-handle part of Virginia.

The right to build the bridge itself was only secured after the act of cession of the State, by a congressional enactment. This bridge was ilt under the general bridge law, approved July 1, 1862. This law quired that the span covering the main channel should leave an unob-ructed passage-way of not less than 300 feet, and "not less than 90 et above low water," "nor less than 40 feet above extreme high water." ith regard to location, the only condition imposed was, that "*the piers uld be parallel with the current* as near as *practicable*."

The conditions imposed were evidently intended to secure a practica-e passage way for vessels of at least 300 feet width at all stages of the er; but the result has been, and will always be, without several other ingent provisions, practically quite different from the intent, if the idge builders merely regard economy in their own constructions. A tement of my observations at this bridge, and the information given , fully illustrate this. The bridge is located in the bend of the Ohio, out one mile above Steubenville. At the time I was there the er was about four feet above low water, and consequently below the al-boat stage. Observations showed the greatest velocity through the annel pier to be at this stage $4\frac{3}{10}$ feet per second, which is about $2\frac{6}{10}$ les per hour. The general velocity of the current, however, was only out two miles per hour at this time. At high stages it must reach miles an hour. The depth of water between the channel piers was out six and a half feet. The water slope, from 400 feet above the bridge 400 feet below it, falls $\frac{22}{100}$ foot. The current passes the bridge at s stage, setting towards the Ohio channel pier and making an angle h it of 15°. This obliquity of itself effects a practical contraction the channel-way of about 10 feet.

The channel-way is still further contracted by a rip-rap thrown around base of the piers, amounting to about 20 feet on all sides, so that practicable channel-way left is only 250 feet instead of 300 feet.

This rip-rap rose at this time two feet above the water, and as the l-boats draw seven feet, there would have to be a rise of nine feet above stage at that time, or 13 feet above low water, before such boats ld pass alongside of the pier.

The location of the bridge, as before said, is in a bend of the river, though at the present time the current sets towards the Ohio re—which it does through the influence of a middle-ground bar—as river rises the influence of the bar is less felt and the current sets more more *into* the bend and on the Virginia shore, and at good coal-boat ges makes an angle impinging against the piers toward that side of river. The current thus has a play of full 30° in different stages at site. It is readily to be seen this must require, on the part of the t, accurate knowledge of the current at each stage so as to enable to make his proper calculation. None, I believe, attempt to pass it

in the night with tows. The currents of the river in bends generally flow on curved lines, so that the boat has a swinging motion as she descends, which of itself requires more room for the boat than where the river is straight; and this is another objection to locating bridges in the bends.

In the towing of coal-boats another great objection to the location of a bridge in the bend arises from the necessity there is for the tug-boat to throw herself and tow obliquely across the stream and back her wheels to keep out from the bank, towards which the surface-current is setting; she is thus unable to pass without danger a bridge in a bend that does not permit by its width of taking the oblique position. The Steubenville bridge, on account of its inadequate width, does not admit of this, and can be passed only by the steamboat going ahead to get steerage-way, thus unavoidably adding her own force to the velocity of the current to increase the shock against the piers or rip-raps should the boats unfortunately strike them. I am informed on the best authority that "in passing those piers they always have hands out on the outer range of boats, with axes ready on the instant of striking, to cut away the striking boat to save the fleet." To make it still worse for the location of this bridge, there is one of the most sudden bends of the Ohio about one and a half mile above it in which the tow-boat has to exert her backing power in the oblique position to the fullest extent, and consequently presents herself near the bridge in the most unfavorable position for passing it by going ahead. The provisions I make in the sections proposed at the end of this report for a new bridge law, practically prohibit the locating of bridges in bends.

Every defect which this location has for navigation might have been avoided by a practicable location about one and a half mile below. There a straight reach and deep pool is found, and a current which does not change its direction at different stages. But it has the disadvantages to the railroad company that the approaches on the Virginia side would have required some expensive excavation to avoid a short curve, and the pier foundations must have been built where the water is 10 feet deep at lowest stages—comparatively trifling objections at the most. Such foundations as the present bridge has should never be used for any important superstructure, and proper foundations could have been built in the proper location as cheaply as they could where the bridge is located.

The following diagram and description exhibit these foundations in a clear manner:

This diagram represents a section across the east channel pier at the Steubenville bridge; at the base it is about 26 by 30 feet. The foundation consists of three courses of pine timber one foot thick decked over with four-inch plank. All the other piers had under them four thicknesses of timber. The natural bed was excavated so that the lowest water would always cover this deck a foot deep. The stone is laid on this in courses two feet thick; the timber projects one foot beyond the masonry, which is, in the first, about 24 feet across at the base with abutter of one half inch per foot rise. The riprap protecting the timber platform extends out about 20 feet on each side, and rises up about six feet above low water at the piers. Nothing but the riprap preserves the piers from destruction, and one of the short piers has deflected about two and a half feet from the perpendicular. The bed is composed of coarse gravel and small and large rounded boulders.

The channel piers are 90 feet above low water and 47 feet above high

water, and 300 feet apart in the clear. The other piers are about $66\frac{7}{10}$ feet above low water. All the spans, of which there are six, beside the main span, exceed 200 feet in the clear. The bridge was built by the Keystone Bridge Company at Pittsburg, after designs by Mr. J. H. Linville. It has wrought iron for the suspension rods and bottom chord, and cast-iron tubes for the uprights and top chord. It is nearly horizontal. The main trusses are about 25 feet high. The track is laid on the bottom chord of the main span, and on the top chord of all the others. It is a beautiful bridge, and with a substitution of wrought iron for the cast-iron parts would be a safe form of structure for longer spans.

The defects of this bridge location, considered from the navigation point of view, which bridge was built under the special provisions of an act of Congress as stringent as any yet enacted, show how insufficient those provisions are for the protection of navigation.

The Rock Island and Clinton bridges, on the Mississippi, are much worse than this, but these were built without any authority from the general government.

The fixing of a proper width of practicable channel-way to be left between piers, so as to not seriously obstruct navigation, and at the same time not to impose any unnecessarily onerous and impracticable conditions on railroads, is a problem of great difficulty, on account of the variety of elements which must be considered. It is not easy to determine what the requirements of navigation may yet be; but the tendency is to demand increased width, and fortunately engineering skill keeps pace with these requirements.

The improvements which have taken place in this country in making permanent bridge foundations and extending the length of the spans, within three years, have rendered almost any requisite span feasible of accomplishment in almost any needed locality.

By the wire suspension plan railroad spans can readily be made 800 to 1,000 feet; and a railroad bridge is now constructed and in operation on the lattice plan, with steel top and bottom members 492 feet clear span.

I think that a drawbridge should never be allowed where the approaches render a high span practicable. Approaches are more difficult on the Mississippi river than on the Ohio, and for this reason a different requirement should be made for the two streams. The difficulty of a boat passing through a given space increases with the velocity of the current, so that for this reason there should be a difference made for different rivers, and for different localities on the same river.

A given amount of difficulty is more and more felt as the number of vessels passing is greater, and in rivers the size of vessels generally increases with their number, because both are greater the lower you descend the river, and the more commerce becomes tributary to it. On this account a greater requirement should be exacted on the lower Mississippi than on the upper Mississippi.

Whatever may be the least limit adopted for the width of the passage-way for boats, I would recommend that the following provisions be required in all cases to secure it. I base these not only on my examination of the Steubenville bridge, but that of many other bridges constructed across the navigable rivers of the west.

Draught of provisions required to secure to navigation the full benefit of one passage-way through bridges across navigable streams, the least width of which passage-way is fixed by law.

Be it enacted, &c. SEC. A. If the design be to allow of the passage of vessels by means of a pivot drawbridge, then there shall be two available openings, one on each side of the pivot pier, neither of a less size than ——— feet in the clear at any stage, and said openings shall be in the main low-water channel of the river.

SEC. B. If the design be to allow of the passage of vessels under a high span, said span shall be across the main low-water channel, and not be less than ——— feet above extreme high water at the lowest part of the bridge, nor shall the piers be less than ——— feet apart in the clear, and a navigable depth of water must be preserved alongside of them at all stages.

[NOTE.—In case the span should be made to exceed 300 feet, it would be sufficient to provide for the minimum elevation of 150 feet each side of the center, and allow the remainder on each side of this to be lower to facilitate the use of upright arches.]

SEC. C. In no case will piers or other supports for the railway be allowed on the water-way occupied by the river while within its bottom land banks, which piers or supports shall leave a space of less than ——— feet in the clear between them, nor shall this water-way be contracted by piers or works of unnecessary size; nor will any ripraps or other material be allowed around the bases of the piers or supports to compensate for inadequate foundations, which material shall contract the passage-way hereinbefore provided for boats, or between the other piers or supports, or which shall injuriously affect the regimen of the river. And *no part* of the bridge over this portion of the river between the piers or other supports shall be less than ——— feet above extreme high water.

SEC. D. All bridges built under the provisions of this act must be located in such places and in such manner as to be perpendicular to the direction of the current in the main channel of the river at all stages, so that the piers of said bridge may be always parallel to the current in this main channel; and the location must also be such that the current of the main channel shall move in a straight line from a point at least 1,000 feet above the bridge to 500 feet below it.

SEC. E. Any party authorized to build a bridge under this act, shall submit to the Secretary of War for his examination a design of the bridge piers, and a map of the location, giving the topography of the banks of the river above and below the location, the shore line at high and low water, the direction of the current at all stages, and the soundings accurately showing the bed of the stream, all for the space of at least one mile above and one mile below the proposed location, and such other information as may be required for a full understanding of the subject. And on the certificate of the Secretary of War that the provisions of the law have been complied with, the building of the piers can be at once commenced.

But if it shall appear that the conditions with regard to the direction of the current cannot be complied with, in the location where the bridge is needed, the Secretary of War shall detail a board composed of not more than three experienced officers of the corps of engineers to consider the case, and may, on their recommendation, sanction the building of the bridge at the proposed location, on such increased spans across the channel-way as the board may deem sufficient to secure a passage-way for boats equivalent to that hereinbefore provided.

APPENDIX H.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, August 15, 1868.

NERAL: I have the honor to submit the following report in reference
e works under my charge, for the fiscal year ending June 30, 1868,
quired by circular dated headquarters corps of engineers, Wash-
n, D. C., June 10, 1868.

OVEMENT OF THE DES MOINES RAPIDS OF THE MISSISSIPPI RIVER.

e plan adopted for this improvement is the same as recommended
e in my report of January 1, 1867, concurred in by the board of
neers convened at Keokuk, Iowa, by Engineer Orders Nos. 18 and
larch 22 and 26, 1867, and approved by the Hon. Secretary of War,
"The construction of a lateral navigation canal, extending along
owa shore a distance of seven and six-tenths miles; 300 feet wide in
nkment, 250 feet wide in excavation; minimum depth 5 feet, with
ift locks and one guard lock, each 350 feet long between gates and 80
ride at the top, and its completion to Montrose by making a thorough
00 feet wide and five feet deep along the natural channel of the
r chain." For the details of the plan adopted I would respectfully
e your attention to my report of January 1, 1867, and to the report
e board of engineers above referred to, submitted to the bureau
13, 1867.

e following instructions from headquarters corps of engineers,
ting me to proceed at once to carry out the plan of improvement
ted by the board, were received by me: * * *

plan for the improvement of the Des Moines rapids of the Mississippi river, by means of
al canal along the Iowa shore, unanimously adopted by the board of engineers, was
ted to the Secretary of War for his decision, in compliance with the act of Congress
ed March 2, 1867.

views of the board in relation to the improvement were concurred in, and the plan
d by the board was recommended by the engineer department to be approved. The

that the bid of Messrs. William Henegan & Son, of Mount Vernon, Ohio, was the lowest, and with whom I was directed, September 17, to enter into contract "to the extent of the funds appropriated, namely: $700,000, reserving sufficient to meet contingent expenses." On the 25th of the same month, the parties having furnished the required bonds, the contract was concluded, and the contractors were directed to commence work without delay. For a detailed statement of the amount of work done, its progress, condition, &c., your attention is invited to the accompanying reports of my assistants, Captain L. C. Overman, United States corps of engineers, and Mr. D. C. Jeune, United States civil engineer. (See Appendices H 1 and H 2.)

In accordance with instructions from headquarters corps of engineers, dated January 29, 1868, directing me to advertise for proposals for furnishing materials and labor for building the locks, the necessary advertisements inviting proposals for the same, to be opened April 15, 1868, were sent to eight of the authorized newspapers, giving six consecutive insertions in each. This portion of the work has been divided into five classes, namely: stone, cement, iron, timber, and labor; copies of the specifications, quantities, &c., have been forwarded to you. Abstracts of proposals (Appendices C, D, and E) are herewith submitted, from which it will be seen that the following named persons are the lowest responsible bidders, and with whom I was directed, May 2, 1868, to enter into contracts whenever there shall be funds available, and upon their complying with the requirements of the law:

Charles E. Tobie, for labor on the guard lock.
James Clark, for all cement.
Charles E. Tobie, for all iron.
R. Nelson Gere, for all timber.
C. G. Case & Co., for stone for the guard and middle locks.
Charles E. Tobie, for stone for lower lock.
E. Owen, for labor on lower lock.
Charles E. Tobie, for labor on middle lock.

As yet no contracts or engagement of any kind have been entered into with any of the above parties. For the entire and permanent completion of this work the sum of $1,480,000, in addition to the $700,000 already appropriated, will be required. At least, enough of this amount to complete the locks should be appropriated without delay, as the parties to whom contracts for materials and labor have been awarded are ready to commence work, and every day they are obliged to wait delays the completion of the improvement a similar length of time.

During the fiscal year ending June 30, 1869, the sum of $850,000, if appropriated, can be profitably expended in the construction of the locks and in making the Montrose improvement, in addition to $430,000 for the excavation of the prism, and for the construction of the embankment wall. This work is located in the first collection district of Iowa. The nearest port is St. Louis, Missouri, at which place there was collected during the last fiscal year—

Import duties	$1,338,296 63
Hospital duties	8,624 46
Tonnage duties	27,195 26
Inspection fees	12,602 76
Storage	2,322 57
Official fees	4,289 35
	1,393,331 03

st two items, *i. e.*, storage and official fees, do not properly
o the revenue account.
undred and twelve steamers, with a registered capacity of
tons, and 98 barges and flats, of 28,572.05 tons, are officially
as belonging to this port.
letailed statement of the amount of commerce and navigation
nefited by this improvement, I would respectfully invite your
to my report of January 1, 1867, since which time no additional
have been collected.
stract of contracts (Appendix H 6) is herewith submitted.
llowing is an exhibit of cash received, expended, and remaining
during the fiscal year ending June 30, 1868:

on hand June 30, 1867		$2,414 04
received from the United States treasury		111,007 98
		113,422 02
to the United States treasury, in obedience to		
r No. 41, dated headquarters corps of engineers,		
ber 7, 1867		5,000 00
		108,422 02
transferred to improvement of the Rock		
rapids	$126 00	
expended*	98,339 54	
		98,465 54
June 30, 1868		9,956 48
appropriated June 23, 1866		$200,000 00
appropriated March 2, 1867		500,000 00
tal		700,000 00
expended during the fiscal year ending		
0, 1868	$98,339 54	
transferred to improvement of the Rock		
rapids	126 00	
expended previous to June 30, 1867	2,585 96	
		101,051 50
applicable June 30, 1868		598,948 50
rom this amount the 15 per cent. retained from		
y estimates of work done by the contractors, as		
y for the performance of their contract		12,270 00
available June 30, 1868		586,678 50

e year ending June 30, 1870, the sum of $1,480,000, the entire
ecessary to complete the work, will be required.
of the various plans, maps, &c., mentioned in the report of
Overman, will be transmitted to the bureau as soon as they
epared.

ount does not include the estimate of work done during the month of June, 1868, to $21,220, including the 15 per cent. retained, which was not paid until July 6.

THE IMPROVEMENT OF THE ROCK ISLAND RAPIDS OF THE MISSISSIPPI RIVER.

The plan recommended and adopted for this improvement is the excavation of the natural channel so as to give a width of 200 feet, and a navigable depth of four feet at extreme low water. It is estimated that about 58,000 cubic yards of rock will have to be removed.

In carrying into effect the instructions of the department, dated Washington, April 10, 1867, it was deemed necessary to obtain additional soundings and a more thorough knowledge of the river bed than was possible in the limited time and means at my disposal during the survey made in the fall of 1866. I therefore directed Brevet Lieutenant Colonel P. C. Hains, captain of engineers, assisted by Lieutenant E. F. Hoffman, 35th infantry, United States army, during the spring of 1867, to make such additional surveys, and to take such soundings on the different chains, as might be necessary to secure accuracy in carrying on the improvement. About 100,000 soundings in all were taken, from which very accurate charts of the river bed have been projected. For a full and interesting description of this survey, and of the ingenious manner in which the soundings were taken, I would respectfully invite your attention to the accompanying report of Lieutenant Hoffman, (Appendix H 8.) Contract for the work having been entered into during the fiscal year ending June 30, 1867, with Messrs. C. G. Case & Co., work was commenced on the 18th of September and continued until the 16th of December, 1867, and again resumed on 21st of April, 1868. For a full, complete and definite account of this work, together with the causes of delay, &c., I would respectfully refer to the report of my assistant, Brevet Major Charles J. Allen, captain corps of engineers, herewith submitted. (Appendix G.) In accordance with instructions from headquarters corps of engineers, dated Washington, D. C., May 4, 1868, an advertisement inviting proposals for continuing this improvement, to be opened at Davenport, Iowa, June 10, was sent to several of the leading authorized newspapers of the country, and given six consecutive insertions in each. But two bids were received, an abstract of which is herewith submitted (Appendix I,) from which it will be seen that the proposal of Messrs. Case, Van Wagener and Harroun, of Fulton, N. Y., was the lowest, their bid being $11 50 per cubic yard, and to whom the award was made in accordance with engineer department letter dated June 20, 1868, with direction to contract with them as soon as an appropriation is made by Congress for continuing the work. No special appropriation was made, however, during this fiscal year. But it is anticipated that a portion of the appropriation made by Congress "for the repair, preservation, extension, and completion of certain public works on harbors and rivers," will be made available for this work, in which case a contract will be made with the above mentioned parties.

About $550,000 will be required for the entire and permanent completion of this improvement, which amount, if appropriated without delay, can be profitably expended during the next fiscal year.

The work is located in the second Iowa collection district, the nearest port of entry is Chicago, Illinois; the collections upon customs at this place is not known.

For a statement of the amount of commerce and navigation which would be benefited by the completion of this work, I would invite your attention to my report of January 1, 1867, since which time no new statistics have been collected. An abstract of proposals received at the letting held at Davenport, Iowa, June 10, 1868, and one of contracts

A. Keefer, was engaged in the examination of the Canal and
kakee to the junction of the latter with the Des Plaines, and
completion of this, in a similar examination of the lower Fox
Aurora. On September 18, the main party had reached La
e lower terminus of the Illinois and Michigan canal, and com-
the resurvey of the river. On October 15, when the party
Chillicothe, Mr. Griffin was relieved from his charge by Civil
r Assistant H. A. Ulffers. In the meantime the party under the
f Mr. Keefer, having finished the examination of Fox river, had
the survey of the lower portion of the Illinois river, beginning
oot of Grand Island and completing their work at Grafton,
e mouth of the Illinois. Connection with their initial point at
of Grand Island was made by the main party on November 8,
npleting the entire survey. The two parties were discharged at
and Peoria, respectively, with the exception of the engineers in
and of Mr. H. G. Palfrey, in charge of the level, who were
to Davenport to work up the results of the survey.

d party had been organized late in August, when the water had
its lowest stage, for the hydrographical survey of the shoaler
the river below La Salle. This party was under the charge
Engineer Assistants L. L. Nichols, and Robert E. McMath, but
nols being obliged to go east for some time, Civil Engineer Assist-
. Ulffers was directed to take charge, until Mr. Nichols should
This party made a careful and minute survey of the river bed
ces where the low water depth was less than four feet, and had
mpleted the work when, unfortunately, the winter season set in,
er 2, with such severity as to render all further operations in the
possible. Mr. McMath was ordered to report at Davenport to
the office work, the rest of the party were finally discharged at

A skeleton map of the Illinois river, on a scale of two inches
ile, based on the surveys of the General Land Office, the several
rveys, and the Preston survey, had already been prepared dur-
fall, by Mr. Matthewson, civil engineer at Lockport. Mr. Keefer
ployed to finish this map, embodying in it all the information
l by the survey. This large map is now finished all but the let-

Mr. McMath made a full report on the hydrography of the

different points of the valley in two sheets, on a scale of four inches to the mile, were drawn by Assistant H. A. Ulffers. A report on the field operation of this survey, embodying also the results of the hydrographical and leveling operations, were prepared and submitted by the same assistant. The results obtained by this survey, combined with those of the former surveys, will furnish all data required for the full consideration of all questions relating to the improvement of the river, except such as relate to the definite location and construction of the dams and locks; to determine these points special surveys will be necessary. The improvement recommended is the widening and deepening of the present canal from Bridgeport to the head of Lake Joliet, with the exception of a section of 11¼ miles between Summit and "The Sag," where it will be cheaper to excavate an independent canal. From Lake Joliet to Marseilles the line is to follow the bed of the river, the necessary depth being secured by a system of dams and locks. At Marseilles construct a piece of independent canal in order to pass the Grand Rapids of the Illinois, striking the river again at or above Ottawa; thence to the mouth of the river the necessary navigation is to be secured by a system of dams and locks. The width of the canal to be not less than 160 feet, and the navigable depth six feet below the lowest known level of the water in Lake Michigan. The present summit level to be cut down so as to secure this depth in the canal from the inexhaustible reservoir of Lake Michigan. The locks to be 350 feet long between the gates, 75 feet wide in the chamber, and to give a minimum draught of seven feet. The slack water of the Illinois to be made so as to secure a navigable depth of seven feet at lowest water.

ESTIMATED COST OF IMPROVEMENT.

1. Chicago to Lockport, 29 miles	$11,249,173 98
2. Lockport to head of Lake Joliet, 7 miles	2,095,546 53
3. Thence to Marseilles, 40 miles,	1,296,806 77
4. Marseilles to Ottawa, 6 miles	938,380 75
5. Ottawa to La Salle, 17 miles	683,734 53
6. La Salle to mouth, 223 miles	1,953,600 00
Total	18,217,242 56

The upper part of the work is located in several collection districts of Illinois.

There is no port of entry near it, nor any fort; the Chicago lighthouse is near its upper terminus. For the amount of commerce and navigation that would be benefited by the completion of this improvement, see report dated Davenport, Iowa, February 15, 1867, which would be increased rather than decreased since that date.

Statement of cash received and expended on account of the examination and survey of western and northwestern rivers, applied to the continuation of the survey of the Illinois river, during the fiscal year ending June 30, 1868:

Amount on hand July 1, 1867	$3,629 69
Amount received from the United States Treasurer	24,190 00
Amount received from the sales of public property	273 25
	28,092 94

Brought forward.....	$28,092 94
deposited to the credit of the Treasurer of the d States.....	273 25
	27,819 69
expended.....	27,124 36
on hand June 30, 1868.....	695 33

warding this report I take the liberty of again calling the atten- he bureau to the necessity of having all the means required to ie improvement of the upper and lower rapids of the Missis- the earliest possible date, so that the entire work may be put ontract and pushed rapidly to completion. The interests of e and navigation demand these improvements, and as no part will be of any advantage till it is all done, it is to be hoped amounts called for in the estimates will be appropriated at an during the next session of Congress. Every year's delay costs itry as much as would be required to defray the expenses of on the improvement for the corresponding period.

also to call attention to that part of my report dated Septem- 867, discussing the difficulty of carrying on public works eco- y under the present system of laws regulating contracts, and to my recommendation for a modification of the same. I take easure in assuring the bureau that there seems to be no reason r for doubting that the improvements now in progress will prove efficacious in removing the present obstructions to navigation at upper and lower rapids, and hence the importance of com- hem as soon as possible. Before closing this report I desire to nd my assistants Brevet Major C. J. Allen, captain United igineers; L. C. Overman, captain United States engineers; E. F. , 2d lieutenant 35th United States infantry; D. S. Jeune, United ivil engineer; H. A. Ulffers, Robert E. McMath, J. P. Frizele, A. Keefer, O. L. Wetmore, and E. Hudson Worrall, civil engi- stants; my clerks, Mr. John P. Hains and Mr. J. W. Mass, and ghtsmen, William Hormuth and C. J. Pauli, to the favor of the These gentlemen have discharged the various laborious and duties with which they have been charged, with marked ability lity.

ery respectfully, your obedient servant,

J. H. WILSON,
Lieutenant Colonel 35th Infantry, Br't Maj. General U. S. A.

Major General A. A. HUMPHREYS,
ief of Engineers, Headquarters Corps of Engineers,
Washington, D. C.

H 1.

Improvement of the Des Moines rapids.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, July 31, 1868.

AL: In accordance with verbal instructions given me on the ant, I have the honor to submit the following report:

, in compliance with engineer orders No. 120, dated headquar-

ters corps of engineers, Washington, District of Columbia, November 5, 1867, reported to you at Davenport, Iowa, I was assigned to duty at Iowa, by the following order:

UNITED STATES ENGINEER OFFICE,
Davenport, Iowa, November 26, 1867.

II. Captain Lewis C. Overman, United States engineers, having reported at this office in pursuance of engineer's orders No. 120, Ex. 7, dated headquarters corps of engineers, November 5, 1867, will proceed to Keokuk, Iowa, at which place he is assigned to duty as inspector of the canal for the improvement of the Des Moines rapids of the Mississippi river. In addition to the duties of inspecting the work as it progresses, Captain Overman is charged with the supervision of the draughting and mapping which may be necessary for that improvement. He will also render himself familiar with the practical use of surveying instruments, and will supervise the estimates of work done, and of funds required, reporting weekly to this office the progress of the work, together with such facts as are of interest or importance. He is particularly charged with the duty of making himself familiar with the reports, plans, and contracts relating to the work, and the gathering of such additional information in reference to it and the hydraulics of the river at the lower rapids, as may be within reach. It is not intended by this order that Captain Overman shall in any way interfere with the duties of Mr. D. C. Jeune, United States civil engineer, in local charge of the construction of the canal.

J. H. WILSON,
Lieut. Col. 35th Infantry, Brevet Maj. Gen. U. S. A.

In addition to the above, verbal instructions were also given me by yourself to investigate the subject of "claims for land damaged or appropriated in the construction of the canal." On the 4th of December, in company with yourself, I proceeded to Keokuk and prepared to follow out the provisions of the above orders. The work of "excavating the prism and constructing the embankment wall" of the canal had been commenced on the 8th of October, by Messrs. Henegan & Son, contractors for the same, but, owing to the small force employed, the work had made but little progress. On November 30, 1867, (four days previous to my arrival,) the condition of the work was as follows: Total amount of earth excavation, 6,584 cubic yards; embankment, 9,756 cubic yards; riprap, 2,575 cubic yards. This was distributed as follows:

At Nashville: Earth excavation, 1,409 cubic yards; embankment, (borrowed,) 4,650 cubic yards; riprap, (borrowed,) 2,390 cubic yards; which formed a river embankment extending from station 32 to station 40×80, a distance of 880 feet, averaging seven feet above surface of water, 16 feet wide on top, and protected by riprap on the outside slope for an average height of five feet.

At Sandusky: Earth excavation, 2,093 cubic yards; riprap, (borrowed,) 185 cubic yards; which formed an embankment on the flats extending from station 186 to station 199, a distance of 1,300 feet, averaging six feet high, seven feet wide on top; the last 200 feet being in the river, was protected on the outside slope by riprap for an average height of five feet above surface of water.

On railroad work: Earth excavation, 3,083 cubic yards; earth embankment, (borrowed,) 9,148 cubic yards; which formed a new line of railroad grade for 5,500 feet. Since that time work has progressed with variable success, at all times slowly, owing principally to want of sufficient men and machinery; at times entirely suspended by the weather, strikes, and high stage of water in the river. Every effort was made, and every means adopted to induce the contractors to push their work more vigorously, and to avail themselves of several favorable opportunities that were offered them. Want of force and a failure on the part of the contractors to realize the magnitude of the improvement, and the work necessary for them to perform, for a long time prevented our efforts being met with a proper response in energy on the part of the contract-

ontinued repetition of these suggestions and urging finally awoke
a proper realization of the condition of affairs. Since that time
k has progressed more satisfactorily. The work performed has,
, as a rule, been of good character, and complies with the
nents of the specifications. A daily record of the progress of
k, together with the force employed, has been kept at this office,
n which weekly and monthly reports have been made to you.
I would respectfully refer for details and particulars. Extreme
ather, ice and storms during January and February, delayed the
nsiderably, while heavy and continued rains during March and
using unusual high water in the river, interfered with its pro-
ll further.

e 30th of June, 1868, the condition of the work was as follows:
nount of earth excavation, 109,153 cubic yards; earth embank-
5,123 cubic yards; lining material, 1,307 cubic yards; riprap,
ubic yards; rock excavation, 1,430 cubic yards; new public road
7 rods; new public road partially built, 150 rods; railroad
1½ mile. Total amount of railroad superstructure changed, 0.64
his work was distributed as follows:

shville: Earth excavation, 13,183 cubic yards; rock excavation,
bic yards; earth embankment, (borrowed,) 14,415 cubic yards;
4,494 cubic yards; which formed a river embankment extend-
station 32 to station 59×50, a distance of 2,750 feet, averaging
above surface of water, 15 feet wide on top, protected on the
slope by riprap for an average height of 10 feet.

rmediate points between Nashville and Rickey's Point: Riprap,
ic yards, which was expended in forming the base or "toe" of
p wall, being six feet wide on top and carried up to surface of
The various points together gave 132,000 feet of this base of
ll borrowed material, except the 1,430 cubic yards of rock exca-

ndusky: Earth excavation, 38,218 cubic yards; riprap, 6,000
rds; which formed an embankment on the flats in the river
g from station 175 to station 215, a distance of 4,000 feet, aver-
feet high, 10 feet wide on top, and protected with riprap on
de slope for an average height of seven feet.

ckey's Point: Earth excavation, 38,707 cubic yards; riprap,
bic yards; which formed an embankment on the flats and in the
ending from station 215 to station 244, a distance of 2,900 feet,
g 12 feet height, 15 feet wide, and protected with riprap on the
or 1,200 feet of the distance, averaging 10 feet in height. The
riprap is extended 850 below the end of the earth bank; aver-
h at surface of water, 4 feet.

ce's creek: Earth excavation, 15,594 cubic yards; riprap, 3,926
rds; which formed an embankment on the flats and in the river
tion 296 to station 315, a distance of 1,900 feet, averaging 9 feet
t, 20 feet wide on top, and protected with riprap on the outside
1,600 feet, averaging six feet in height. The "toe" of riprap
ded 1,300 feet below the end of the earth embankment, and
4 feet wide at surface of water.

lroad work: earth excavation, 3,451 cubic yards; earth embank-
,708 cubic yards; lining material, 996 cubic yards; change of line
ad, 0.637 mile; public road completed, 150 rods. This formed a
road grade for one and a half mile, and the ties and iron have
nged on 0.637 mile. It will be seen from the above that thus
contractors have not performed their due proportion of the

work assigned them, in order to complete the same in the time called for by the terms of the contract. The total amount of work done up to June 30, 1868, has been $103,020; whereas to complete the work in the contract time, their estimates should have amounted to $225,000.

Steps have been taken to hurry on the work, and, from present appearances, their future estimates will be much heavier. The various field operations for the above work were performed for a time by Civil Engineer Assistants E. Bennett and J. H. Striedinger, then by Civil Engineer Assistants E. Bennett and E. H. Worrall, and finally by Civil Engineer Assistants O. L. Wetmore and E. H. Worrall. The above, with the necessary chainmen, rodmen, &c., were employed daily during this time in locating the line of canal, taking levels for the same, laying out and superintending work, taking soundings, estimating quantities of work performed monthly, and in calculating monthly estimates; all under the general supervision of United States Civil Engineer D. C. Jeune and myself.

OFFICE WORK.

The following maps, plans, &c., have been prepared up to June 30, 1868, by Civil Engineer Assistant G. A. Keefer and W. Hormuth:

1. Map showing approximate location of centre line of canal, (two sheets.)
2. Profile of the Iowa shore from Nashville to Keokuk.
3. Profile of the Illinois shore from Nashville to Keokuk.
4. Plat of soundings taken in Nashville harbor, with tracings, (two sheets.)
5. Plat of soundings taken in Keokuk harbor, with tracings, (two sheets.)
6. Plat of soundings taken in vicinity of Price's creek, with tracings, (two sheets.)
7. General profile of embankment with tracings of same.
8. General plan for railroad bridges on the new line of railroad, (three sheets,) with tracings of same.
9. Maps showing proposed location of guard lock, with tracing.
10. Maps showing proposed location of middle lock, with tracing.
11. Maps showing proposed location of lower lock, with tracing.
12. Maps showing approved location of guard lock, with tracing.
13. Maps showing approved location of middle lock, with tracing.
14. Maps showing approved location of lower lock, with tracing.
15. General map of the Des Moines Rapids of the Mississippi river, on three sheets, with tracings.
16. Maps showing location and quantity of land damaged by the construction of canal, four sheets, with tracings.
17. Plan of the guard lock in duplicate.
18. Plan of the middle lock in duplicate.
19. Plan of the lower lock in duplicate.
20. Plan of the pier at head of guard lock.
21. Plan of the pier at foot of lower lock.
22. Plan showing details of recess corners of locks.
23. Plan showing details of hollow quoins of locks.
24. Plan showing details of mitre sills of locks.
25. Plan showing details of valve platforms of locks.
26. Plan showing details of iron work for locks.

* In addition to the above there has been plotted a cross-section of

* Nos. 12, 13, and 14, and 17 to 26, were prepared for the letting of the lock work, which took place April 15, 1868.

canal taken at right angle to the axis for every 50 feet of the axis, ving the surface ground and bed of river as passed over by the l. These cross-sections give the amount of excavation and fill at e points, and approximately for the neighboring 50 feet.
om these cross-sections, thus taken, the approximate monthly esti- es are calculated.
nsiderable time and labor has been given by Assistant G. A. Keefer e finishing up of a map showing the result of the survey between Michigan and the Mississippi, along the line of the Illinois and its itaries, for the best line for a proposed ship canal between the lake river.

LAND DAMAGES.

t the earliest opportunity consistent with other duties I proceeded rry out your verbal instructions regarding claims for land damaged appropriated for the use of the canal. I found that Mr. Alonzo rmore, civil engineer, and formerly an assistant on this improve- t, had, previous to my arrival, been directed to make similar investi- ns. He had located nearly all claims of parties interested, ascer- d the owners of said land, caused surveys of the boundaries of and to be made, and had approximate maps of the said land plotted. pon the 10th of December I addressed a circular letter to all parties ing claims against the government, calling upon them to inform me what terms they were willing to settle their claims with the gov- ent. Upon information thus furnished, I drew up a report in which those who were willing to make a settlement at the average price milar land" were embodied in one class, while those whose claims, y opinion, were unreasonable, but who were willing to settle under ld laws of Iowa, formed a second class. This report was forwarded he 20th of December, 1867, and was by you forwarded to the engi- department.
the 8th of January, 1868, I received through Brevet Major C. J. n, an official copy of a communication addressed to you by the engi- department, of which the following is a copy:

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 3, 1868.

ERAL: A special appropriation will be asked to indemnify the owners of property possession of or damaged by the construction of the canal around the Des Moines , and to cover the law expenses incident to the proper adjudication of the claims or.

ppears from the report of Captain Overman, transmitted by you with your letter of the f December, that the claims of those willing to make a reasonable settlement (class 1 report) amount to $15,500; but the list of those willing to leave their claims to a jury 2) is incomplete, and no estimate of the whole probable amount required can be made rom in this office. You will, therefore, transmit estimates in detail showing the names ners, amount of land damaged by occupation, overflow, or otherwise; amount of crops ged, improvements to be removed or destroyed, &c., &c., as well as amount required al services and other incidental expenses, that the same may be submitted to the Sec- of War for the purpose above mentioned.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

vet Major General J. H. WILSON,
Lieutenant Colonel 35th Infantry, Davenport, Iowa.

compliance with the above letter, I forwarded on the 14th of Janu- 1868, an approximate estimate of the quantity and value of land ged by this improvement, with an approximate estimate of the

funds required to settle the classes for said lands. This estimate was, I think, forwarded by you to the engineer department.

As the laws of the State of Iowa were found to be inadequate for the case, it was deemed advisable to have, if possible, a special law passed covering the case. Through the kindness and influence of ex-Governor Lowe, of Iowa, such a bill was drawn up and presented to the legislature of the State, and was by them passed during their last session.

In conformity with and under the articles of this law, a commission of freeholders was appointed in April by the sheriff of Lee county, who proceeded to investigate and decide all claims arising out of this improvement. This commission has not yet finished its labors, so that no report of their proceedings can be furnished.

Copies of all papers, maps, &c., concerning the subject, which were in the possession of this office, were furnished the commission, and every aid given them.

The United States district attorney of the State of Iowa, having notified me on the 22d of January that he had been directed by the Attorney General of the United States to take charge of and represent the government in all suits connected with this improvement to which it (the government) was a party, and at the same time having notified me that his assistant, Hon. D. F. Miller, would represent him, I authorized the said Hon. D. F. Miller to attend to these claims and represent the government before the commission.

The fact that no authority to negotiate the right of way was granted in the bill making the appropriation for this improvement, and the consequent inability of the officer in charge to make any arrangements with the land-owners, has been not only a source of much vexation, trouble, and delay, but will eventually result in considerable pecuniary loss to the government. Had authority been granted in the bill to use a portion of the appropriation to pay for the right of way, favorable terms could in most cases have been secured with the claimants, as they all preferred to settle without appeal to law, and would have taken much less per acre, with the amount of claim paid immediately, than under the uncertainty which now exists; besides coming before a commission with their claims, they put the amount of said claim at the highest figure. In one or two instances permission to enter upon the land until the claim had been settled was refused, and injunctions were taken out to restrain us from trespassing. These, of course, were the source of much delay, but were finally compromised or withdrawn.

Respectfully submitted.

L. COOPER OVERMAN,
Captain Corps of Engineers.

Brevet Major General J. H. WILSON, U. S. A.,
Lieutenant Colonel 35th Infantry.

H 2.

Improvement of the Des Moines Rapids.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, July 9, 1868.

GENERAL: In compliance with your verbal instructions, I have the honor to make the following report of the progress of the work for the improvement of the navigation of the Mississippi river, at Des Moines

or Lower rapids, during the fiscal year ending June 30, 1868, and its condition at that date.

The section-work of the canal for this improvement was placed under contract on the 25th of September, 1867, with Messrs. William and John Henegan, of Mount Vernon, Ohio, at prices contained in their proposals presented at a letting held at Davenport, Iowa, September 4, 1867. The aggregate of their bid for the work was $711,659, which was $438,684 below the estimated cost. On the 8th of October the contractors commenced work at the head of the canal at Nashville, by building a temporary guard-bank from the shore at head of guard-lock out to the line of embankment, as a necessary step preparatory to extending down the river the outside canal bank and riprap wall. Since that time this work has slowly progressed, at all times, (except during the high water in the river in the months of March, April, and May,) and at this date the bank and outside riprap wall is nearly completed for 1,200 feet. The foundation of the riprap wall has been extended 4,100 feet further, and a portion of the bank built, inside of the foundation of the riprap, for about 1,600 feet of this last distance. On the 22d of October the grading of the new line for the change in the Keokuk and St. Paul railway was commenced, and the work mostly completed in the month of November. The new line is one and a half mile long, extending from Sandusky depot south to Rickey's station. About one-half of the track or superstructure has been changed from the old to this new line, and the balance will be in the next 10 days.

About the 20th of November the excavation of prism and forming the bank of canal was commenced on the Sandusky cut, three miles below Nashville. The bank across the cut, a distance of 2,000 feet, has all been formed and the outside rip-rap nearly completed. The river bank across the bay between this and the Rickey cut, a distance of 2,000 feet has all been commenced, including the outside foundation of the riprap and about nine-tenths of the earth bank, and one-half of the riprap wall has been put in.

On the 1st of December the excavation of the cut at Rickey's was commenced. The bank across the same, a distance of 1,200 feet, has been formed, and extended into the river below for 1,450 feet. The outside riprap wall, across the cut and on the river bank below for 700 feet, is very nearly completed, and the foundation is extended 850 feet further. About the 20th of January a large force of men were set to work forming the foundation of riprap on the ice, betweeen Nashville and Sandusky, and up to the 20th of February one and a half mile had been put in between these points, but the ice failing at that time left one mile untouched. The contractors are now engaged in putting in this portion with boats, and from present appearances it will all be put in and raised above the surface of water in the river during the month of July.

On the 13th of March the excavation of prism and forming bank of canal was commenced at the cut below Price's creek. The bank is all formed across this cut a distance of 1,500 feet, and the outside riprap put in, except 150 feet at the head of the middle lock, which has been left for the convenience of the construction of this lock. The foundation of the riprap has been extended into the river below 1,600 feet and the embankment 600 feet.

The section work has not progressed as rapidly as the contract for the same requires. During the months of March, April, and May, the work was delayed by high water in the river, but prior to March 1, and since May 18, there was no delay from that source. Work has been commenced on half the entire length of the canal, and yet only about one-

eighth part of the work has been performed. The contractors have been specially directed and will be required to put in the foundation of all the bank and riprap walls between Nashville and Sandusky, a distance of two and a half miles, entirely in the river, during the present summer, and get it all above high-water mark before winter sets in. There is estimated 160,000 cubic yards of rock to be excavated in the prism of canal and from the present bed of the river on the first one and a half mile below Nashville. As soon as the embankment above referred to is all commenced, and put in shape as required, the river will be entirely shut out; the water will draw down below and leave this rock dry, so that the excavation can be driven rapidly, and the inside and outside riprap walls for this bank built from the excavated rock.

There can be no doubt of the completion of this work by the time the locks are finished, even with a full appropriation for the locks at this session of Congress.

A very careful revision of the estimates of quantities of work to be done has been made, and at the contractors' prices, (which are very low, and I have no faith in their completing the work at their prices,) the cost of section-work will not exceed $800,000, which is 250,000 below the original estimated cost.

On the 15th of April last bids were received for furnishing the materials and performing all the labor for constructing the locks, except the gates. The prices bid were below the original estimates, and the work has all been awarded to the lowest bidders, who, it is confidently believed, are practical men and competent to perform the work at the prices stipulated. The contracts will be made and the work commenced as soon as the appropriation bill passes Congress. The work has now so far progressed and such developments of its character made as to be a sure guaranty that the improvement of these rapids, by the construction of a canal and locks, will not exceed the estimate made and attached to the report of the commissioners appointed by the Secretary of War under a resolution of Congress to devise the plan of improvement, including all expenses for engineering, land damages, and miscellaneous expenditures.

The amount of work performed on the canal up to the 30th day of June is as follows:

Bailing and draining	$134 12
1,430 cubic yards excavation of rock, at $1 35	1,930 50
109,153 cubic yards excavation of earth, at 33 cents	36,020 49
25,123 cubic yards embankment, at 37 cents	9,295 51
1,307 cubic yards lining, at 40 cents	522 80
40,268 39/100 cubic yards loose stone in riprap walls, at $1 35	54,362 33
0.637 miles changing railroad track, at $500	318 50
127 rods constructing public road, at $2 25	285 75
150 rods constructing public road, partially built, at $1	150 00
Total work done	103,020 00

The average amount per month is $11,446, and the amount in the month of June was $21,220.

Respectfully submitted.

DANIEL C. JENNE,
United States Civil Engineer.

Brevet. Maj. Gen. J. H. WILSON, U. S. A.,
Lieutenant Colonel 35th Infantry.

H 3.—*Abstract of proposals received at the United States engineer office at Keokuk, Iowa, April 15, 1868, for materials and labor for the guard lock for the improvement of the Des Moines rapids of the Mississippi river.*

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 1.—Cement.						
				Hydraulic cement, 4,160 casks.		Use of one limehouse for storing cement.		Attention and care of cement.		Aggregate.
				Rate.		*Rate.*		*Rate.*		
1	C. G. Case & Co., Fulton, N. Y...	W. Johnson and S. F. Case, Fulton, N. Y.	O. L. Wetmore.....	$3 00	$12,480 00	$200	$200 00	$100	$100 00	$12,780 00
2	M. Sellers & Co., Keokuk, Iowa..	R. S. Ruddick and J. D. Baughman, Keokuk.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....
3	R. W. McClaughry & Co., Keokuk, Iowa.	A. C. Connable and G. B. Smyth, Keokuk.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....
4	Chas. E. Tobie, Utica, N. Y.....	P. Tobie and J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	3 63	15,100 80	1,000	1,000 00	416	416 00	16,516 80
5	E. Owen, Albany, N. Y.....	J. McDonald and P. V. Fort, Albany, N. Y.	Jos. Davis, postmaster, Albany, N. Y.	.....	.....	.....	.....	.....	.....	.....
6	C. and J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio...	.....	.....	.....	.....	.....	.....	.....	.....
7	Barnard and Gowen, Chicago, Ill..	C. L. Woodman and J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	3 80	15,808 00	624	624 00	416	416 00	16,848 00
8	Ledlie and Corse, Chicago, Ill....	C. Fitzsimons and James Mallery, Chicago, Ill.	F. Myer, deputy quartermaster general United States army.	.....	.....	.....	.....	.....	.....	.....
9	M. M. Rhorer, Louisville, Ky.....	J. F. Speed and J. W. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	3 70	15,392 00	.....	.....	.....	.....	15,392 00
10	T. C. Clark, Quincy, Ill.....	G. B. Dimmock and C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....
11	R. Nelson Gere, Syracuse, N. Y...	E. Van Dusen and N. S. Gere, Geddes, N. Y.	H. Manger, postmaster.....	3 00	12,480 00	300	300 00	100	100 00	12,880 00
12	Jno. Loler, St. Louis Mo.....	G. A. Fillay and J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	.....	.....	.....	.....	.....	.....	.....
13	James Clark, Utica, Ill.....	Barnard and Gowen, Chicago, Ill..	.....	2 60	10,816 00	125	125 00	200	200 00	*11,141 00
14	Jas. H. Mallery, Lemont, Ill.....	Ledlie, Corse & Co., Chicago, Ill....	.....	.....	.....	.....	.....	.....	.....	.....
15	Jno. Napier, Keokuk, Iowa.....	A. Hine and A. L. Connable, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....
16	J. B. Night, Keokuk, Iowa.....	J. A. Viall and C. Hubble, Keokuk, Iowa.	J. C. Parrott, postmaster.....	.....	.....	.....	.....	.....	.....	.....
17	Jno. McCune, Keokuk, Iowa.....	J. Madden and H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....
18	J. and E. Skelsey & Co., Keokuk, Iowa.	D. W. Pressell and J. A. McDowell, Keokuk, Iowa.	J. M. Reid, United States commissioner.	.....	.....	.....	.....	.....	.....	.....

* Lowest on cement.

Abstract of proposals received at the United States engineer office at Keokuk, Iowa, April 15, 1868, for materials and labor, &c.—Continued.

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 1.—Stone.								
				Face stone, 3 323 cubic yards.		Backing stone, 4,660 cubic yds.		Rubble stone for vertical or battered wall, 6,300 cubic yards.		Rubble stone for slope wall 770 cubic yds.		Aggreg'te.
				Rate.		*Rate.*		*Rate.*		*Rate.*		
1	C. G. Case & Co., Fulton, N. Y.	W. Johnson and S. F. Case, Fulton, N. Y.	O. L. Wetmore	$6 00	$19,938 00	$4 00	$18,640 00	$4 00	$25,200 00	$1 25	$962 50	*$64,740 50
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick and J. D. Baughman, Keokuk.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	R. W. McClaughry & Co., Keokuk, Iowa.	A. C. Connable and G. B Smyth, Keokuk.	W. W. Belknap, collector of internal revenue.	10 00	33,230 00	7 00	32,620 00	6 00	37,800 00	3 00	2,310 00	105,960 00
4	Chas. E. Tobie, Utica, N. Y...	P. Tobie and J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	6 90	22,928 70	4 25	19,805 00	4 25	26,775 00	2 50	1,925 00	71,433 70
5	E. Owen, Albany, N. Y.....	J. McDonald and P. V. Fort, Albany, N. Y.	Jos. Davis, postmaster, Albany, N. Y.	6 50	21,599 50	5 00	23,300 00	3 50	22,050 00	1 50	1,155 00	68,104 50
6	C. and J Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	Barnard & Oowen, Chicago, Illinois.	C. L. Woodman and J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	0 00	29,907 00	7 00	32,600 00	6 00	37,800 00	5 00	3,850 00	104,177 00
8	Ledlie & Corse, Chicago, Ill...	C. Fitzsimons and James Mallery, Chicago, Ill.	F. Myer, deputy quartermaster U. S. A.	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	M. H. Rhorer, Louisville, Ky.	J. F. Speed and J. W. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	T. C. Clark, Quincy, Ill.....	G. B. Dimmock and C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	R. Nelson Gere, Syracuse, N. Y	E. Van Duesen and N. S. Gere, Geddes, N. Y.	H. Manger, postmaster....	7 00	23,261 00	6 50	30,290 00	5 00	31,500 00	2 00	1,540 00	86,591 00
12	Jno. Loler, St. Louis, Mo....	G. A. Fillay and J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	10 00	34,891 50	7 00	32,620 00	7 00	44,100 00	4 00	3,080 00	114,691 50
13	Jas. Clark, Utica, Ill.....	Barnard & Gowen, Chicago, Ill..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	Jas. H. Mallery, Lemont, Ill..	Ledlie, Corse & Co., Chicago, Ill	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	Jno. Napier, Keokuk, Iowa..	A. Hine and A. L. Connable, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	J. B. Night, Keokuk, Iowa....	J. A. Viall and C. Hubble, Keokuk, Iowa.	J. C. Parrott, postmaster..	10 00	33,230 00	7 00	32,620 00	6 00	37,800 00	2 00	1,540 00	105,190 00
17	Jno. McCune, Keokuk, Iowa..	J. Madden and H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	8 75	29,076 00	7 40	34,484 00	7 40	46,620 00	2 50	1,925 00	112,105 25
18	J. and E. Skelsey & Co., Keokuk, Iowa.	D. W. Presseil and J. A. McDowell, Keokuk, Iowa.	J. M. Reid, United States commissioner.	.....	.....	.....	.....	.....	.....	.....	.....	.....

Abstract of proposals received at the United States engineer office at Keokuk, Iowa, April 15, 1868, for materials and labor, &c.—Continued.

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No 2.—Iron.				Class No. 3.—Lumber.				
				Wrought iron, 10,000 pounds.		Cast iron, 4,000 pounds.		Aggregate.	White oak timber, 20,000 feet, board measure.		White pine or hemlock, 100,000 feet, board measure.	Aggreg'te.
				Rate.		Rate.			Rate.		Rate.	
1	C. G. Case & Co., Fulton, N. Y.	W. Johnson and S. F. Case, Fulton, N. Y.	O. L. Wetmore.....	$0 13	$1,300 00	$0 10	$400 00	$1,700 00	$80 00	$1,600 00	$50 00	$5,000 00	$6,600 00
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick, and J. D. Baughman, Keokuk.	W. W. Belknap, collector of internal revenue.	09	900 00	07	280 00	1,180 00	.....	.....	.....	.....	.....
3	R. W. McClaughry & Co., Keokuk, Iowa.	A. C. Connable and G. B. Smyth, Keokuk.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	Chas. E. Tobie, Utica, N. Y.	P. Tobie and J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	08	800 00	09	360 00	*1,160 00	.....	.....	.....	.....	.....
5	E. Owen, Albany, N. Y....	J. McDonald and P. V. Fort, Albany, N. Y.	Jos. Davis, postmaster, Albany, N. Y.	.....	.....	.....	.....	.....	75 00	1,500 00	40 00	4,000 00	5,500 00
6	C. and J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.	.....	12	1,200 00	13	520 00	1,720 00	.....	.....	.....	.....	.....
7	Barnard & Gowen, Chicago, Illinois.	C. L. Woodman and J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	15	1,500 00	12	480 00	1,980 00	100 00	2,000 00	80 00	8,000 00	10,000 00
8	Ledlie & Corse, Chicago, Ill.	C. Fitzsimons and Jas. Mallery, Chicago, Ill.	F. Myers, dep'y quartermaster general U. S. A.	.....	.....	.....	.....	.....	64 90	1 298 00	48 90	4,890 00	6,188 00
9	M. M. Rhorer, Louisville, Ky.	J. F. Speed and J. W. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	T. C. Clark, Quincy, Ill....	G. B. Dimmock and C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	R. Nelson Gere, Syracuse, N. Y.	E. Van Duzen and N. S. Gere, Geddes, N. Y.	H. Manger, postmaster	11¼	1,175 00	09	360 00	1,535 00	35 00	700 00	35 00	3,500 00	†4,200 00
12	Jno. Loler, St. Louis, Mo..	G. A. Fillay and J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
13	Jas. Clark, Utica, Ill.....	Barnard & Gowen, Chicago, Illinois.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	Jas. H. Mallery, Lemont, Ill.	Ledlie, Corse & Co., Chicago, Illinois.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	Jno. Napier, Keokuk, Iowa.	A. Hine and A. L. Connable, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	J. B. Night, Keokuk, Iowa	J. A. Viall and C. Hubble, Keokuk, Iowa.	J. C. Parrott, postmaster.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	Jno. McCune, Keokuk, Iowa,	J. Madden and H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
18	J. and E. Skelsey & Co., Keokuk, Iowa.	D. W. Pressell and J. A. McDowell, Keokuk, Iowa.	J. M. Reid United States commissioner.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

* Lowest on iron.

† Lowest on lumber.

Abstract of proposals received at the United States engineer office at Keokuk, Iowa, April 15, 1868, for materials and labor, &c.—Continued.

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Bailing and draining.	Earth excavation, 30,460 cubic yards.		Rock excavation, 37,480 cubic yards.		Earth embankment, 10,000 cubic yards.		Lining, 3,000 cubic yards.	
					Rate.		*Rate.*		*Rate.*		*Rate.*	
1	C. G. Case & Co., Fulton, N. Y.	W. Johnson and S. F. Case, Fulton, N. Y.	O. L. Wetmore.....	$5,000 00	$0 40	$12,184 00	$3 25	$121,810 00	$0 45	$4,500 00	$0 50	$1,500 00
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick and J. D. Baughman, Keokuk.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	R. W. McClaughry & Co., Keokuk, Iowa.	A. C. Connable and G. B. Smyth, Keokuk.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	Chas. E. Tobie, Utica, N. Y..	P. Tobie and J. F. Kerrigan, Utica, N. Y.	L Blakeslee, United States collector.	28,147 00	30	9,138 00	1 75	65,590 00	40	4,000 00	45	1,350 00
5	E. Owen, Albany, N. Y.....	J. McDonald and P. V. Fort, Albany, N. Y.	Jos. Davis, postmaster, Albany, N. Y.	6,000 00	50	15,230 00	3 30	123,684 00	40	4,000 00	70	2,100 00
6	C. and J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	Barnard & Gowen, Chicago, Illinois.	C. L. Woodman and J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	30,000 00	70	21,322 00	3 00	112,440 00	70	7,000 00	1 50	4,500 00
8	Ledlie & Corse, Chicago, Ill..	C. Fitzsimons and James Mallery, Chicago, Ill.	F. Myer, deputy quartermaster general U. S. A.	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	M. M. Rhorer, Louisville, Ky.	J. F. Speed and J. W. Henning, Louisville Ky.	P. Speed, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	T. C. Clark, Quincy, Ill.....	G. B. Dimmock and C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	20,000 00	35	10,661 00	1 75	65,590 00	35	3,500 00	1 00	3,000 00
11	R. Nelson Gere, Syracuse, N. Y.	E. Van Dusen and N. S. Gere, Geddes, N. Y.	H. Manger, postmaster....	10,000 00	25	7,615 00	2 00	84 960 00	45	4,500 00	80	2,400 00
12	Jno. Loler, St. Louis, Mo....	G. A. Fillay and J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	20,000 00	50	15,230 00	4 00	149,920 00	50	5,000 00	1 00	3,000 00
13	James Clark, Utica, Ill.....	Barnard & Gowen, Chicago, Illinois.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	Jas. H. Mallery, Lemont, Ill..	Ledlie, Corse & Co., Chicago, Illinois.	.....	10,000 00	40	12,184 00	2 50	93,700 00	60	6,000 00	75	2,250 00
15	Jno. Napier, Keokuk, Iowa..	A. Hine and A. L. Connable, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	18,000 00	45	13,707 00	2 25	84,330 00	40	4,000 00	1 00	3,000 00
16	J. B. Night, Keokuk, Iowa....	J. A. Viall and C. Hubble, Keokuk, Iowa.	J. C. Parrott, postmaster..	55,000 00	55	16,753 00	3 00	112,440 00	60	6,000 00	55	1,650 00
17	Jno. McCune, Keokuk, Iowa..	J. Madden and H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	40,000 00	67	20,408 20	3 50	131,180 00	50	5,000 00	1 00	3,000 00
18	J. and E. Skelsey & Co., Keokuk, Iowa.	D. W. Presnell and J. A. McDowell, Keokuk, Iowa.	J. M. Reid, United States commissioner.	29,750 00	1 00	30,460 00	.....	84,330 00	65	6,500 00	73	2,190 00

Abstract of proposals received at the United States engineer office at Keokuk, Iowa, April 15, 1868, for materials and labor, &c.—Continued.

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Loose stone, 3,430 cubic yards.		Puddling, 2,500 cubic yards.		Constructing slope wall, 770 cubic y'ds.		Constructing vertical or battered wall, laid in cement, 4,500 cubic yards.		Constructing vertical or battered wall, laid dry, 1,800 cubic yards.	
				Rate.		Rate.		Rate.		Rate.		Rate.	
1	C. G. Case & Co., Fulton, N. Y.	W. Johnson and S. F. Case, Fulton, N. Y.	O. L. Wetmore	$1 25	$4,287 50	$0 20	$500 00	$0 75	$577 50	$2 00	$9,000 00	$2 00	$3,600 00
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick and J. D. Baughman, Keokuk.	W. W. Belknap, collector of int'l revenue.										
3	R. W. McClaughry & Co., Keokuk, Iowa.	A. C. Connable and G. B. Smyth, Keokuk.	W. W. Belknap, collector of int'l revenue.										
4	Chas. E. Tobie, Utica, N. Y.	P. Tobie and J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	2 00	6,860 00	30	750 00	1 50	1,155 00	2 00	9,000 00	2 00	3,600 00
5	E. Owen, Albany, N. Y.	J. McDonald and P. V. Fort, Albany, N. Y.	Jos. Davis, postmaster, Albany, N. Y.	1 50	5,145 00	25	625 00	75	577 50	2 00	9,000 00	2 00	3,600 00
6	C. and J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.											
7	Barnard & Gowen, Chicago Illinois.	C. L. Woodman and J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	1 50	5,145 00	40	1,000 00	2 50	1,925 00	5 00	22,500 00	4 00	7,200 00
8	Ledlie & Corse, Chicago, Ill.	C. Fitzsimons and Jas. Mallery, Chicago, Ill.	F. Myer, deputy quartermaster general U. S. A.										
9	M. M. Rhorer, Louisville, Kentucky.	J. F. Speed and J. W. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.										
10	T. C. Clark, Quincy, Ill.	G. B. Dimmock and C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	1 00	3,430 00	1 00	2,500 00	3 00	2,310 00	5 00	22,500 00	5 00	9,000 00
11	R. Nelson Gere, Syracuse, N. Y.	E. Van Dusen and N. S. Gere, Geddes, N. Y.	H. Manger, postmaster	80	2,744 00	15	375 00	60	462 00	3 00	13,500 00	2 00	2,600 00
12	Jno. Loler, St. Louis, Mo.	G. A. Fillay and J. W. Bell, St. Louis, Mo	L. M. Breckenridge, acting collector.	2 25	7,717 50	1 50	3,750 00	2 25	1,732 50	6 00	27,000 00	4 00	7,200 00
13	Jas. Clark, Utica, Ill.	Barnard & Gowen, Chicago, Illinois.											
14	Jas. H. Mallery, Lemont, Ill.	Ledlie, Corse & Co., Chicago, Ill.		1 50	5,145 00	25	625 00	1 00	770 00	3 00	13,500 00	3 00	5,400 00
15	Jno. Napier, Keokuk, Iowa.	A. Hine and A. L. Connable, Keokuk, Iowa.	W. W. Belknap, collector of int'l revenue.	1 00	3,430 00	40	1,000 00	1 50	1,155 00	3 75	16,875 00	2 75	4,950 00
16	J. B. Night, Keokuk, Iowa.	J. A. Viall and C. Hubble, Keokuk, Iowa.	J. C. Parrott, postmaster	1 50	5,145 00	60	1,500 00	2 00	1,540 00	4 50	20,250 00	3 00	5,400 00
17	Jno. McCune, Keokuk, Iowa.	J. Madden and H. W. Sample, Keokuk Iowa.	W. W. Belknap, collector of int'l revenue.	1 60	5,488 00	1 25	3,125 00	1 00	770 00	3 50	15,750 00	3 00	5,400 00
18	J. and E. Skelsey & Co., Keokuk, Iowa.	D. W. Presnell and J. A. McDowell, Keokuk, Iowa.	J. M. Reid, United States commissioner.	2 00	6,860 00	80	2,000 00	2 75	2,117 50	4 50	20,250 00	3 75	6,750 00

Abstract of proposals received at the United States engineer office at Keokuk, Iowa, April 15, 1868, for materials and labor, &c.—Continued.

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Concrete masonry, 400 cubic yards.		Constructing masonry in lock walls, 7,983 cubic yards.		White oak timber, preparing, dressing, and putting into work, 20,000 feet, b. m.		White pine or hemlock, preparing, dressing, and putting into work 100,000 ft., b. m.		Wrought-iron, handling & putting in 10,000 pounds.		Cast-iron, handling and putting in 4,000 pounds.	
				Rate.		*Rate.*		*Rate.*		*Rate.*		*Rate.*		*Rate.*	
1	C. G. Case & Co. Fulton, N. Y.	W. Johnson and S. F. Case, Fulton, N. Y.	O. L. Wetmore.....	$5 00	$2,000 00	$6 00	$47,898 00	$35 00	$700 00	$15 00	$1,500 00	$0 05	$500 00	$0 05	$200 00
2	M. Sellers Co., Keokuk, Iowa.	R. S. Ruddick and J. D. Baughman, Keokuk.	W. W. Belknap, collector of int'l revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	R. W. McClaughry & Co., Keokuk, Iowa.	A. C. Connable and G. B. Smyth, Keokuk.	W. W. Belknap, collector of int'l revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	Chas. E. Tobie, Utica, N. Y.	P. Tobie and J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	10 00	4,000 00	6 22	49,654 26	15 00	300 00	15 00	1,500 00	05	500 00	04	160 00
5	E. Owen, Albany, N. Y.	J. McDonald and P. V. Fort, Albany, N. Y.	Jos. Davis, postmaster, Albany, N. Y.	5 00	2,000 00	6 50	51,689 50	30 00	600 00	20 00	2,000 00	08	800 00	06	240 00
6	C. and J. Cooper, Mt. Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	Barnard & Gowen, Chicago, Ill.	C. L. Woodman and J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	5 00	2,000 00	12 00	95,796 00	15 00	300 00	10 00	1,000 00	04	400 00	04	160 00
8	Ledlie & Corse, Chicago, Ill.	C. Fitzsimons and James Mallery, Chicago, Ill.	F. Myer, deputy quartermaster gen'l U. S. A.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	M. M. Rhorer, Louisville, Ky.	J. F. Speed and J. W. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	T. C. Clark, Quincy, Illinois.	G. B. Dimmock and C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	6 00	2,400 00	11 00	87,813 00	30 00	600 00	27 00	2,700 00	05	500 00	10	400 00
11	R. Nelson Gere, Syracuse, N. Y.	E. Van Dusen and N. S. Gere, Geddes, N. Y.	H. Manger, postmaster.	5 00	2,000 00	8 00	63,864 00	1 00	20 00	1 00	100 00	03	300 00	03	120 00
12	Jno. Loler, St. Louis, Mo.	G. A. Fillay and J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	4 00	1,600 00	10 50	83,821 50	10 00	200 00	5 00	500 00	05	500 00	05	200 00
13	James Clark, Utica, Illinois.	Barnard & Gowen, Chicago, Ill.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	Jas. H. Mallery, Lemont, Ill.	Ledlie, Corse & Co., Chicago, Ill.	.....	3 50	1,400 00	10 50	83,821 50	20 00	400 00	10 00	1,000 00	10	1,000 00	08	320 00
15	Jno. Napier, Keokuk, Iowa.	A. Hine and A. L. Connable, Keokuk, Iowa.	W. W. Belknap, collector of int'l revenue.	5 00	2,000 00	9 50	75,838 50	20 00	400 00	10 00	1,000 00	12	1,200 00	12	480 00
16	J. B. Night, Keokuk, Iowa.	J. A. Viall and C. Hubble, Keokuk, Iowa.	J. C. Parrott, postmaster.	9 50	3,800 00	9 85	78,632 55	03	600 00	03	3,000 00	10	1,000 00	10	400 00
17	Jno. McCune, Keokuk, Iowa.	J. Madden and H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of int'l revenue.	2 50	1,000 00	8 00	63,864 00	5 00	100 00	.....	no bid	.....	no bid	.....	no bid.
18	J. and E. Skelsey & Co., Keokuk, Iowa.	D. W. Pressell and J. A. McDowell, Keokuk, Iowa.	J. M. Reid, United States commissioner.	8 45	3,380 00	8 25	65,859 75	02½	500 00	02	2,000 00	07	700 00	05	200 00

Abstract of proposals received at the United States ...

Number of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Wrought spikes and nails, handling, &c., 4,000 lbs.		Lead and antimony, 500 pounds.		Sulphur and sand for cement.		Aggregate.	Grand aggregate.
				Rate.		*Rate.*		*Rate.*			
1	C. G. Case & Co., Fulton, N. Y..	W. Johnson and S. F. Case, Fulton, N. Y.	O. L. Wetmore.....	$0 12	$480 00	$0 25	$125 00	$5.0	$500 00	$216, 862 00	$302, 682 50
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick and J. D. Baughman, Keokuk.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....
3	R. W. McClaughry & Co. Keokuk, Iowa.	A. C. Connable and G. B. Smyth, Keokuk.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....
4	Chas. E. Tobie, Utica, N. Y.....	P. Tobie and J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	03	120 00	10	50 00	100	100 00	*185, 974 26	.....
5	E. Owen, Albany, N. Y.....	J. McDonald and P. V. Fort, Albany, N. Y.	Jos. Davis, postmaster, Albany, N. Y.	12	480 00	20	100 00	500	500 00	228, 571 00	.....
6	C. and J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio..	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	Barnard & Gowen, Chicago, Ill	C. L. Woodman and J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	10	400 00	25	125 00	200	200 00	313, 413 00	446, 418 00
8	Ledlie & Corse, Chicago, Ill....	C. Fitzsimons and James Mallery, Chicago, Ill.	F. Myer, deputy quartermaster general United States army.	.....	.....	.....	.....	.....	.....	.....	.....
9	M. M. Rhorer, Louisville, Ky...	J. F. Speed and J. W. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....
10	T. C. Clark, Quincy, Ill.....	G. B. Dimmock and C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	10	400 00	1 00	500 00	.....	no bid	237, 804 00	.....
11	R. Nelson Gere, Syracuse, N. Y.	E. Van Dusen and N. S. Gere, Geddes, N. Y.	H. Manger, postmaster.....	03	120 00	20	100 00	200	200 00	†186, 980 00	.....
12	Jno. Loler, St. Louis, Mo.....	G. A. Filley and J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	10	400 00	12	60 00	25	25 00	327, 856 50	292, 246 00
13	Jas. Clark, Utica, Ill	Barnard & Gowen, Chicago, Ill....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	Jas. H. Mallery, Lemont, Ill...	Ledlie, Corse & Co., Chicago, Ill...	.....	05	200 00	75	375 00	500	500 00	238, 590 00	.....
15	Jno. Napier Keokuk, Iowa....	A. Hine and A. L. Connable, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	12	480 00	25	125 00	100	100 00	232, 070 50	.....
16	J. B. Night, Keokuk, Iowa....	J. A. Viall and C. Hubble, Keokuk, Iowa.	J. C. Parrott, postmaster.....	10	400 00	25	125 00	50	50 00	313, 685 55	.....
17	Jno. McCune, Keokuk, Iowa,..	J. Madden and H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	no bid	.....	no bid	.....	no bid	295, 585 20	.....
18	J. and E. Skelsey & Co., Keokuk, Iowa.	D. W. Pressell and J. A. McDowell, Keokuk, Iowa.	J. M. Reid, United States commissioner.	10	400 00	42	210 00	150	150 00	264, 607 25	.....

* Lowest for labor. † R Nelson Gere asks permission, by a subsequent proposition, received April 16, and filed with his proposal for labor for guard lock, to reduce his bid on item "bailing and draining" to $8,800, which, if accepted, would make this bid the lowest for labor by $194 26; I would respectfully recommend that the contract be awarded to him. For particulars see letter of transmittal.

J. H. WILSON.
Lieut. Col. 35th Infantry, Bvt. Maj. General U. S. A.

UNITED STATES ENGINEER OFFICE, *Keokuk, Iowa, August* 18, 1868.

H 4.—*Abstract of proposals received at the United States engineer office at Keokuk, Iowa, April 15, 1868, for materials and labor for the middle lock for the improvement of the Des Moines rapids of the Mississippi river.*

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 1—Cement.						
				Hydraulic cement, 3,000 casks.		Use of one lime house for storing cement.		Attention and care of cement.		Aggregate.
				Rate.		*Rate.*		*Rate.*		
1	Chas. G. Case & Co., Fulton, N. Y.	W. Johnson and F. S. Case, Fulton, N. Y.	O. L. Wetmore	$3 00	$10,800 00	$200	$200 00	$100	$100 00	$11,100 00
2	M. Sellers & Co., Keokuk, Iowa	R. S. Ruddick and J. D. Baughman, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.							
3	R. W. McClaughry & Co., Keokuk, Iowa.	A. L. Connable and G. B. Smyth, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.							
4	Chas. E Tobie, Utica, N. Y	P. Tobie and J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	3 63	13,068 00	1,000	1,000 00	360	360 00	14,428 00
5	E. Owen, Albany, N. Y	J. McDonald and P. W. Fort, Albany, N. Y.	J. Davis, postmaster, Albany, N. Y.							
6	C. & J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio								
7	Barnard & Gowen, Chicago, Ill	C. L. Woodman and J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	3 80	13,680 00	540	540 00	360	360 00	14,580 00
8	Ledlie & Corse, Chicago, Ill	C. Fitzsimons and J. H. Mallery, Chicago, Ill.	F. Myers, deputy quartermaster general United States army.							
9	Robt. McHenry, Fort Madison, Iowa.	J. H. Bacon and O. Cutler, Fort Madison, Iowa.	W. W. Belknap, collector of internal revenue.							
10	M. M. Rhorer, Louisville, Ky	J. F. Speed and J. H. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	3 70	13,320 00					13,320 00
11	Thos. C. Clark, Quincy, Ill	G. B. Dimmock and C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.							
12	R. Nelson Gere, Syracuse, N. Y	E. B. Van Dusen and W. S. Gere, Geddes, N. Y.		3 00	10,800 00	300	300 00	100	100 00	11,200 00
13	Steel & Fletcher, Keokuk, Iowa	C. Hubble and J. A. Viall, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.							
14	Jno. Sheehan, St. Louis, Mo	G. F. Filley and J. W. Bell, St. Louis, Mo.								
15	Jno. Loler, St. Louis, Mo	G. F. Filley and J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.							
16	Jas. Clark, Utica, Ill	Barnard & Gowen, Chicago, Ill		2 60	9,360 00	125	125 00	200	200 00	*9,685 00
17	Jas. Mallery, Lemont, Ill	Ledlie & Corse, Chicago, Ill	F. Myers, deputy quartermaster general United States army.							
18	Jno. Napier, Keokuk, Iowa	A. Hine and A. L. Connable, Keokuk, Iowa.								
19	Jno. McCune, Keokuk, Iowa	J. Madden and H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.							
20	J. & E. Skelsey & Co., Keokuk, Iowa.	D. W. Bressell and J. A. McDowell, Keokuk, Iowa.	J. M. Reid, United States commissioner.							

* Lowest for cement.

Abstract of proposals received at the United States engineer office at Keokuk, Iowa, April 15, 1868, for materials and labor, &c.—Continued.

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 1—Stone.								
				Face stone, 3,050 cubic yards.		Backing stone, 5,656 cubic yards.		Rubble stone for vertical or battered wall, 3,080 cubic yards.		Rubble stone for slope wall, 200 cubic yards.		Aggreg'te.
				Rate.		*Rate.*		*Rate.*		*Rate.*		
1	Chas. G. Case & Co., Fulton, N. Y.	W. Johnson and F. S. Case, Fulton, N. Y.	O. L. Wetmore	$7 00	$21,350 00	$4 00	$22,424 00	$4 00	$12,320 00	$1 25	$250 00	*$56,344 00
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick and J. D. Baughman, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	R. W. McClaughry & Co., Keokuk, Iowa.	A. L. Connable and G. B. Smyth, Keokuk, Iowa.	W. W Belknap, collector of internal revenue.	10 00	30,500 00	7 00	39,242 00	6 00	18,480 00	3 00	600 00	88,822 00
4	Chas. E. Tobie, Utica, N. Y..	P. Tobie and J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	6 90	21,045 00	4 25	23,825 50	4 25	13,090 00	2 50	500 00	58,460 50
5	E. Owen, Albany, N. Y.....	J. McDonald and P. W. Fort, Albany, N. Y.	J. Davis, postmaster, Albany, N. Y.	6 00	18,300 00	4 50	25,227 00	3 50	10,780 00	1 50	300 00	†54,607 00
6	C. & J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	Barnard & Gowen, Chicago, Illinois.	C. L. Woodman and J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	9 00	27,450 00	7 00	39,242 00	6 00	18,480 00	5 00	1,000 00	86,172 00
8	Ledlie & Corse, Chicago, Ill..	C. Fitzsimons and J. H. Mallery, Chicago, Ill.	F. Myers, deputy quartermaster general U. S. A.	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	Robt. McHenry, Fort Madison, Iowa.	J. H. Bacon and O. Cutler, Fort Madison, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	M. M. Rhorer, Louisville, Ky..	J. F. Speed and J. H. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	Thos. C. Clark, Quincy, Ill....	G. B. Dimmock and C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	R. Nelson Gere, Syracuse, N. Y.	E. B. Van Dusen and W. S. Gere, Geddes, N. Y.	.....	7 00	21,350 00	6 50	36,439 00	5 00	15,400 00	2 00	400 00	73,589 00
13	Steel & Fletcher, Keokuk, Iowa.	C. Hubble and J. A. Viall, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	9 00	27,450 00	5 00	28,930 00	5 00	15,400 00	1 50	300 00	71,180 00
14	Jno. Sheehan, St. Louis, Mo..	G. F. Filley and J. W. Bell, St. Louis, Mo.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	Jno. Loler, St. Louis, Mo.....	G. F. Filley and J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	11 50	35,075 00	7 00	39,242 00	7 00	21,560 00	4 00	800 00	96,677 00
16	Jas. Clark, Utica, Ill.....	Barnard & Gowen, Chicago, Ill..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	Jas. Mallery, Lemont, Ill.....	Ledlie & Corse, Chicago, Ill....	F. Myers, deputy quartermaster general U. S. A.	.....	.....	.....	.....	.....	.....	.....	.....	.....
18	Jno. Napier, Keokuk, Iowa...	A. Hine and A. L. Connable, Keokuk, Iowa.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
19	Jno. McCune, Keokuk, Iowa..	J. Madden and H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	8 75	26,687 50	7 40	41,484 40	7 40	22,192 00	2 50	500 00	91,463 90
20	J. & E. Skelsey & Co., Keokuk, Iowa.	D. W. Bressell and J. A. McDowell, Keokuk, Iowa.	J. M. Reid, United States commissioner.	.....	.....	.....	.....	.....	.....	.....	.....	.....

* Next lowest for stone, to whom the contract should be awarded.
† Lowest for stone; Proposes to furnish the stone provided the contract for the labor be awarded to him, and is therefore considered void.

Abstract of proposals received at the United States engineer office at Keokuk, Iowa, April 15, 1868, for materials and labor, &c.—Continued.

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 2—Iron.					Class No. 3—Lumber.				
				Wrought-iron, 10,000 pounds.		Cast-iron, 4,000 pounds.		Aggregate.	White oak timber, 40,000 feet, board measure.		White pine or hemlock, 100,000 feet, board measure.		Aggreg'te.
				Rate.		*Rate.*			*Rate.*		*Rate.*		
1	Chas. G. Case & Co., Fulton, N. Y.	W. Johnson and F. S. Case, Fulton, N. Y.	O. L. Wetmore	$0 13	$1,300 00	$0 10	$400 00	$1,700 00	$80 00	$3,200 00	$50 00	$5,000 00	$8,200 00
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick and J. D. Baughman, Keokuk, Iowa.	W. W. Belknap, collector of int'l revenue.	09	900 00	7	280 00	1,180 00					
3	R. W. McClaughry & Co., Keokuk, Iowa.	A. L. Connable and G. B. Smyth, Keokuk, Iowa.	W. W. Belknap, collector of int'l revenue.										
4	Chas. E. Tobie, Utica, N. Y.	P. Tobie and J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	8	800 00	9	360 00	*1,160 00					
5	E. Owen, Albany, N. Y.	J. McDonald and P. W. Fort, Albany, N. Y.	J. Davis, postmaster, Albany, N. Y.						75 00	3,000 00	40 00	4,000 00	7,000 00
6	C. & J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.		12	1,200 00	13	520 00	1,720 00					
7	Barnard & Gowen, Chicago, Ill.	C. L. Woodman and J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	15	1,500 00	12	480 00	1,980 00	100 00	4,000 00	80 00	8,000 00	12,000 00
8	Ledlie & Corse, Chicago, Ill.	C. Fitzsimons and J. H. Mallery, Chicago, Ill.	F. Myers, deputy quartermaster gen'l U S. A.						64 90	2,596 00	48 90	4,890 00	7,486 00
9	Robt. McHenry, Fort Madison, Iowa.	J. H. Bacon and O. Cutler, Fort Madison, Iowa.	W. W. Belknap, collector of int'l revenue.										
10	M. M. Rhorer, Louisville, Ky.	J. F. Speed and J. H. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.										
11	Thos. C. Clark, Quincy, Ill.	G. B. Dimmock and C. E. Allen Quincy, Ill.	J. Grisham, collector of internal revenue.										
12	R. Nelson Gere, Syracuse, N. Y.	E. B. Van Dusen and W. S. Gere, Geddes, N. Y.		11½	1,175 00	9	360 00	1,535 00	35 00	1,400 00	35 00	3,500 00	†4,900 00
13	Steel & Fletcher, Keokuk, Iowa.	C. Hubble and J. A. Viall, Keokuk, Iowa.	W. W. Belknap, collector of int'l revenue.										
14	Jno. Sheehan, St. Louis, Mo.	G. F. Fillay and J. W. Bell, St. Louis, Mo.											
15	Jno. Loler, St. Louis, Mo.	G. F. Fillay and J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.										
16	Jas. Clark, Utica, Ill.	Barnard & Gowen, Chicago, Ill.											
17	Jas. Mallery, Lemont, Ill.	Ledlie & Corse, Chicago, Ill.	F. Myers, deputy quartermaster gen'l U.S.A.										
18	Jno. Napier, Keokuk, Iowa.	A. Hine and A. L. Connable, Keokuk, Iowa.											
19	Jno. McCune, Keokuk, Iowa.	J. Madden and H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of int'l revenue.										
20	J. & E. Skelsey & Co., Keokuk, Iowa.	D. W. Bressell and J. A. McDowell, Keokuk, Iowa.	J. M. Reid, United States commissioner.										

* Lowest for iron.

† Lowest for lumber.

No. of proposal	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 4— Labor.								
				Bailing and draining.	Earth excavation, 24,200 cubic yds.		Rock excavation, 12,560 cubic yds.		Earth embankm't, 5,000 cubic yds.		Lining, 3,000 cubic yards.	
					Rate.		*Rate.*		*Rate.*		*Rate*	
1	Chas. G. Case & Co., Fulton, N. Y.	W. Johnson and F. S. Case, Fulton, N. Y.	O. L. Wetmore	$6,000 00	$0 40	$9,680 00	$3 00	$37,680 00	$0 45	$2,250 00	$0 65	$1,950 00
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick and J. D. Baughman, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.									
3	R. W. McClaughry & Co., Keokuk, Iowa.	A. L. Connable and G. B. Smyth, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.									
4	Chas. E. Tobie, Utica, N. Y.	P. Tobie and J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	2,000 00	30	7,260 00	1 75	21,980 00	40	2,000 00	45	1,350 00
5	E. Owen, Albany, N. Y.	J. McDonald and P. W. Fort, Albany, N. Y.	J. Davis, postmaster, Albany, N. Y.	6,000 00	40	9,680 00	2 50	31,400 00	40	2,000 00	70	2,100 00
6	C. & J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.										
7	Barnard & Gowen, Chicago, Illinois.	C. L. Woodman and J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	15,000 00	70	16,940 00	3 00	37,680 00	70	3,500 00	1 50	4,500 00
8	Ledlie & Corse, Chicago, Ill.	C. Fitzsimons and J. H. Mallery, Chicago, Ill	F. Myers, deputy quartermaster general U. S. A.									
9	Robt. McHenry, Fort Madison, Iowa.	J. H. Bacon and O. Cutler, Fort Madison, Iowa.	W. W. Belknap, collector of internal revenue.	10,000 00	50	12,100 00	2 25	28,260 00	60	3,000 00	1 50	4,500 00
10	M. M. Rhorer, Louisville, Ky.	J. F. Speed and J. H. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.									
11	Thos. C. Clark, Quincy, Ill.	G. B. Dimmock and C. E Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	10,000 00	35	8,740 00	1 75	21,980 00	35	1,750 00	1 00	3,000 00
12	R. Nelson Gere, Syracuse, N. Y.	E. B. Van Dusen and W. S. Gere, Geddes, N. Y.		5,000 00	30	7,260 00	3 00	37,680 00	60	3,000 00	90	2,700 00
13	Steel & Fletcher, Keokuk, Iowa.	C. Hubble and J. A. Viall, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	10,000 00	50	12,100 00	2 25	28,260 00	50	2,500 00	1 00	3,000 00
14	Jno. Sheehan, St. Louis, Mo.	G. F. Fillay and J. W. Bell, St. Louis, Mo.		11,000 00	50	12,100 00	4 00	50,240 00	40	2,000 00	1 10	3,300 00
15	Jno. Loler, St. Louis, Mo	G. F. Fillay and J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.									
16	Jas. Clark, Utica, Ill.	Barnard & Gowen, Chicago, Illinois.										
17	Jas. Mallery, Lemont, Ill.	Ledlie & Corse, Chicago, Ill.	F. Myers, deputy quartermaster general U. S. A.	8,000 00	40	9,680 00	3 00	37,680 00	60	3,000 00	75	2,250 00
18	Jno. Napier, Keokuk, Iowa.	A. Hine and A. L. Connable, Keokuk, Iowa.		9,000 00	45	10,890 00	2 25	28,260 00	40	2,000 00	1 00	3,000 00
19	Jno. McCune, Keokuk, Iowa.	J. Madden and H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	15,000 00	50	12,100 00	3 00	37,680 00	40	2,000 00	1 00	3,000 00
20	J. & E. Skelsey & Co., Keokuk, Iowa.	D. W. Bressell and J. A. McDowell, Keokuk, Iowa.	J. M. Reid, United States commissioner.	19,500 00	85	20,570 00	2 00	25,120 00	49	2,450 00	58	1,740 00

Abstract of proposals received at the United States engineer office at Keokuk, Iowa, April 15, 1868, for materials and labor, &c.—Continued.

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 4—Labor.											
				Loose stone, 1,000 cub. yds.		Puddling, 2,500 cub. yds.		Constructing slope wall, 200 cubic yds.		Construct'g vertical or battered wall, laid in cement, 2,200 cubic yards.		Construct'g vertical or battered wall, laid dry, 880 cubic yards.		Concrete masonry, 400 cubic yards.	
				Rate.		*Rate.*		*Rate.*		*Rate.*		*Rate.*		*Rate.*	
1	Chas. G. Case & Co., Fulton, N. Y.	W. Johnson and F. S. Case, Fulton, N. Y.	O. L. Wetmore	$1 65	$1,650	$0 25	$625	$1 00	$200	$2 50	$5,500	$2 50	$2,200	$6 00	$2,400
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick and J. D. Baughman, Keokuk, Iowa.	W. W. Belknap, collector of int'l revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	R. W. McClaughry & Co., Keokuk, Iowa.	A. L. Conrable and G. B. Smyth, Keokuk, Iowa.	W. W. Belknap, collector of int'l revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	Chas. E. Tobie, Utica, N. Y.	P. Tobie and J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	2 00	2,000	30	750	1 50	300	2 00	4,400	2 00	1,760	10 00	4,000
5	E. Owen, Albany, N. Y.	J. McDonald and P. W. Fort, Albany, N. Y.	J. Davis, postmaster, Albany, N. Y.	1 50	1,500	25	625	1 00	200	1 75	3,850	1 75	1,540	5 00	2,000
6	C. & J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	Barnard & Gowen, Chicago, Ill.	C. L. Woodman and J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	1 50	1,500	40	1,000	2 50	500	5 00	11,000	4 00	3,520	5 00	2,000
8	Ledlie & Corse, Chicago, Illinois.	C. Fitzsimons and J. H. Mallery, Chicago, Ill.	F. Myers, deputy quartermaster gen'l U.S.A.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	Robt. McHenry, Fort Madison, Iowa.	J. H. Bacon and O. Cutler, Fort Madison, Iowa.	W. W. Belknap, collector of int'l revenue.	1 00	1,000	2 00	5,000	3 00	600	4 00	8,800	2 00	1,760	3 50	1,400
10	M. M. Rhorer, Louisville, Ky.	J. F. Speed and J. H. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	Thos. C. Clark, Quincy, Illinois.	G. B. Dimmock and C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	1 00	1,000	1 00	2,500	3 00	600	5 00	11,000	5 00	4,400	6 00	2,400
12	R. Nelson Gere, Syracuse, N. Y.	E. B. Van Dusen and W. S. Gere, Geddes, N. Y.	.....	90	900	20	500	3 00	600	3 50	7,700	3 00	2,640	5 00	2,000
13	Steel & Fletcher, Keokuk, Iowa.	C. Hubble and J. A. Viall, Keokuk, Iowa.	W. W. Belknap, collector of int'l revenue.	75	750	50	1,200	1 00	200	2 50	5,500	1 50	1,320	6 00	2,400
14	Jno. Sheehan, St. Louis, Missouri.	G. F. Fillay and J. W. Bell, St. Louis, Mo.	.....	1 90	1,900	1 40	3,500	2 25	450	5 00	11,000	4 00	3,960	3 90	1,560
15	Jno. Loler, St. Louis, Missouri.	G. F. Fillay and J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	Jas. Clark, Utica, Ill.	Barnard & Gowen, Chicago, Ill.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	Jas. Mallery, Lemont, Ill.	Ledlie & Corse, Chicago, Ill.	F. Myers, deputy quartermaster gen'l U.S.A.	1 50	1,500	25	625	1 00	200	3 00	6,600	3 00	2,640	3 50	1,400
18	Jno. Napier, Keokuk, Iowa.	A. Hine and A. L. Connable, Keokuk, Iowa.	.....	1 00	1,000	1 00	1,500	1 50	300	4 00	8,800	3 00	2,640	5 00	2,000
19	Jno. McCune, Keokuk, Iowa.	J. Madden and H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of int'l revenue.	1 60	1,600	1 25	3,125	1 00	200	3 25	7,150	3 00	2,640	2 50	1,000
20	J. & E. Skelsey & Co., Keokuk, Iowa.	D. W. Bressell and J. A. McDowell, Keokuk, Iowa.	J. M. Reid, United States commissioner.	2 00	2,000	75	1,875	2 50	500	4 50	9,900	3 75	3,300	8 45	3,380

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 4—Labor.									
				Constructing masonry in lock walls, 8,656 cubic yards.		White oak timber, preparing, dressing, and putting into work, 40,000 feet, b'rd measure.		White pine or hemlock, preparing, dressing, and putting into work, 100,000 feet, b .m		Wrought iron, handling and putting in, 10,000 pounds.		Cast iron, handling and putting in, 4,000	
				Rate.		*Rate.*		*Rate.*		*Rate.*		*Rate.*	
1	Chas. G. Case & Co., Fulton, N. Y.	W. Johnson and F. S. Case, Fulton, N. Y.	O. L. Wetmore	$7 50	$64,920 00	$35 00	$1,400 00	$15 00	$1,500 00	$0 05	$500 00	$0 05	$200 00
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick and J. D. Baughman, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	R. W. McClaughry & Co., Keokuk, Iowa.	A. L. Connable and G. B. Smyth, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	Chas. E. Tobie, Utica, N. Y.	P. Tobie and J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, U. S. collector.	6 22	53,840 32	15 00	600 00	15 00	1,500 00	5	500 00	4	160 00
5	E. Owen, Albany, N. Y....	J. McDonald and P. W. Fort, Albany, N. Y.	J. Davis, postmaster, Albany, N. Y.	6 00	51,936 00	30 00	1,200 00	20 00	2,000 00	8	800 00	6	240 00
6	C. & J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	Barnard & Gowen, Chicago, Ill.	C. L. Woodman and J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	8 00	69,248 00	15 00	600 00	10 00	1,000 00	4	400 00	4	160 00
8	Ledlie & Corse, Chicago, Ill	C. Fitzsimons and J. H. Mallery, Chicago, Ill.	F. Myers, deputy quartermaster general U. S. A.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	Robt. McHenry, Fort Madison, Iowa.	J. H. Bacon and O. Cutler, Fort Madison, Iowa.	W. W. Belknap, collector of internal revenue.	12 00	103,872 00	30 00	1,200 00	25 00	2,500 00	7 00	700 00	6 00	240 00
10	M. M. Rhorer, Louisville, Ky	J. F. Speed and J. H. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	Thos. C. Clark, Quincy, Ill..	G. B. Dimmock and C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	10 37	89,762 72	30 00	1,200 00	27 00	2,700 00	5	500 00	10	400 00
12	R. Nelson Gere, Syracuse, N. Y.	E. B. Van Duzen and W. S. Gere, Geddes, N. Y.	.....	7 00	60,592 00	1 00	40 00	1 00	100 00	5	500 00	5	200 00
13	Steel & Fletcher, Keokuk, Iowa.	C Hubble and J. A. Viall, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	8 75	75,740 00	2½	1,000 00	2½	2,500 00	8	800 00	5	200 00
14	Jno. Sheehan, St. Louis, Mo.	G. F. Fillay and J. W. Bell, St. Louis, Mo.	.....	10 25	88,724 00	6 00	240 00	3 00	300 00	4	400 00	4	160 00
15	Jno. Loler, St. Louis, Mo..	G. F. Fillay and J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	Jas. Clark, Utica, Ill.....	Barnard & Gowen, Chicago, Illinois.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	Jas. Mallery, Lemont, Ill...	Ledlie & Corse, Chicago, Ill..	F. Myers, deputy quartermaster general U. S. A.	9 50	82,232 00	15 00	600 00	10 00	1,000 00	10	1,000 00	5	200 00
18	Jno. Napier, Keokuk, Iowa.	A. Hine and A. L. Connable, Keokuk, Iowa.	.....	8 90	77,938 40	20 00	800 00	10 00	1,000 00	12	1,200 00	12	480 00
19	Jno. McCune, Keokuk, Iowa.	J. Madden and H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	8 00	69,248 00	5 00	200 00	5 00	500 00	.....	No bid.	.....	No bid
20	J. & E. Skelsey & Co., Keokuk, Iowa.	D. W. Bressell and J. A. McDowell, Keokuk, Iowa.	J. M. Reid, United States commissioner.	7 50	64,920 00	2½	1,000 00	2	2,000 00	7	700 00	5	200 00

Abstract of proposals received at the United States engineer office at Keokuk, Iowa, April 15, 1868, *for materials and labor, &c.*—Continued.

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 4—Labor.							Grand aggreg'te.
				Wrought spikes and nails, handling, &c., 4,000 lbs.		Lead and antimony, 500 pounds.		Sulphur and sand for cement.		Aggregate.	
				Rate.		*Rate.*		*Rate.*			
1	Chas. G. Case & Co., Fulton, N. Y.	W. Johnson and F. S. Case, Fulton, N.Y.	O. L. Wetmore	$0 12	$480	$1 25	$125	$500	$500	$139, 760 00	$217, 104
2	M. Sellers & Co., Keokuk, Iowa,	R. S. Ruddick and J. D. Baughman, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....
3	R. W. McClaughry & Co., Keokuk, Iowa.	A. L. Connable and G. B. Smyth, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....
4	Chas. E. T. bie, Utica, N. Y	P. Tobie and J. F. Kerrigan, Utica, N.Y.	L. Blakeslee, United States collector....	3	120	10	50	100	100	*104, 670 32	.....
5	E. Owen, Albany, N. Y.....	J. McDonald and P. W. Fort, Albany, N Y.	J. Davis, postmaster, Albany, N. Y.....	12	480	20	100	500	500	118, 151 00	.....
6	C. & J. Cooper, Mt. Vernon, Ohio	G. A. Jones, Mount Vernon, Ohio....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	Barnard & Gowen, Chicago, Ill...	C. L. Woodman and J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill..	10	400	25	125	200	200	169, 273 00	284, 605
8	Ledlie & Corse, Chicago, Ill	C. Fitzsimons and J. H. Mallery, Chicago, Ill.	F. Myers, deputy quartermaster general United States army.	.....	.....	.....	.....	.....	.....	.....	.....
9	Robt. McHenry, Fort Madison, Iowa.	J. H. Bacon and O. Cutler, Fort Madison, Iowa.	W. W. Belknap, collector of internal revenue.	5	200	20	100	200	200	185, 432 00	.....
10	M. M. Rhorer, Louisville, Ky.....	J. F. Speed and J. H. Henning, Louisville, Ky.	P. Speed, collector of internal revenue..	.....	.....	.....	.....	.....	.....	.....	.....
11	Thos. C. Clark, Quincy, Ill.....	G. B. Dimmock and C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue	10	400	1 00	500	.....	(†)	162, 562 72	.....
12	R. Nelson Gere, Syracuse, N. Y..	E. B. Van Dusen and W. S. Gere, Geddes, N. Y.	.....	5	200	25	125	200	200	131, 937 00	223, 161
13	Steel & Fletcher, Keokuk, Iowa..	C. Hubble and J. A. Viall, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	10	400	20	100	25	25	148, 045 00	.....
14	Jno. Sheehan, St. Louis, Mo.....	G. F. Fillay and J. W. Bell, St. Louis, Missouri.	.....	11	440	13	65	30	30	191, 369 00	.....
15	Jno. Loler, St. Louis, Mo.....	G. F. Fillay and J. W. Bell, St. Louis, Missouri.	L. M. Breckenridge, acting collector....	.....	.....	.....	.....	.....	.....	.....	.....
16	Jas. Clark, Utica, Ill.....	Barnard & Gowen, Chicago, Ill	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	Jas. Mallery, Lemont, Ill	Ledlie & Corse, Chicago. Ill.....	F. Myers, deputy Q. M. G. U. S. army ..	15	200	75	375	500	500	159, 682 00	.....
18	Jno. Napier, Keokuk, Iowa	A. Hine and A. L. Connable, Keokuk, Iowa.	.....	12	480	25	125	100	100	151, 613 40	.....
19	Jno. McCune, Keokuk, Iowa.....	J. Madden and H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	(†)	.....	(†)	.....	(†)	155, 443 00	.....
20	J. & E. Skelsey & Co, Keokuk, Iowa.	D. W. Bressell and J. A. McDowell, Keokuk, Iowa.	J. M. Reid, United States commissioner..	10	400	42	210	150	150	159, 915 00	.....

* Lowest for labor.

† No bid.

J. H. WILSON, *Lieut. Col. 35th Inf., Bvt. Maj. Gen. U. S. A.*

UNITED STATES ENGINEER OFFICE, *Keokuk, Iowa, August* 18, 1868.

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 1.—Cement.						
				Hydraulic cement, 5,480 casks.		Use of lime-house for storing cement.		Attention and care of cement.		Aggregate.
				Rate.		*Rate.*		*Rate.*		
1	C. G. Case & Co., Fulton, N. Y...	W. Johnson, S. F. Case, Fulton, N.Y.	O. L. Wetmore	$3 00	$16,440 00	$200	$200 00	$100	$100 00	$16,740 00
2	M. Sellers & Co., Keokuk, Iowa..	R. S. Ruddick, J. B. Baughman, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....
3	R. M. McClaughry & Co., Keokuk, Iowa.	A. L. Connable, G. B. Smythe, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....
4	Chas. E. Tobie., Utica, N. Y	P. Tobie, J. F. Kerrigan, Utica, N.Y.	L. Blakeslee, United States collector.	3 63	19,892 40	1,000	1,000 00	548	548 00	21,440 40
5	E. Owen, Albany, N. Y.....	J. S. McDonald, P. V. Fort, Albany, N. Y.	J. Davis, postmaster, Albany, N.Y.	.....	.....	.....	.....	.....	.....	.....
6	C. and J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio ..	.....	.....	.....	.....	.....	.....	.....	.....
7	Barnard & Gowen, Chicago, Ill...	C. L. Woodman, J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	3 80	20,824 00	822	822 00	548	548 00	22,194 00
8	Leddie & Corse, Chicago, Ill	O. Fitzsimons, J. H. Mallery, Chicago, Ill.	F. Myers, deputy quartermaster general United States army.	.....	.....	.....	.....	.....	.....	.....
9	Brown, Bandon & Co., Dayton, Ohio.	S. N. Brown, F. B. Stevenson, Dayton, Ohio.	T. J. Wood, brevet major general United States army.	.....	.....	.....	.....	.....	.....	.....
10	M, M. Rhorer, Louisville, Ky.....	J. F. Speed, W. H. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	3 70	20,276 00	.....	.....	.....	.....	20,276 00
11	T. C. Clark, Quincy, Ill.....	G. B. Dimmock, C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....
12	R. Nelson Gere, Syracuse, N. Y..	E. B. Van Dusen, N. S. Gere, Geddes, N. Y.	H. Manger, postmaster.....	3 00	16,440 00	300	300 00	100	100 00	16,840 00
13	Jno. Loler, St. Louis, Mo.....	G. A. Fillay, J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	.....	.....	.....	.....	.....	.....	.....
14	Jas. Clark, Utica, Ill.....	Barnard & Gowen, Chicago, Ill.....	.....	2 60	14,248 00	150	150 00	200	200 00	*14,598 00
15	J. H. Mallery, Lemont, Ill	Ledlie & Corse, Chicago, Ill	F. Myers, deputy quartermaster general United States army.	.....	.....	.....	.....	.....	.....	.....
16	Jno. Napier, Keokuk, Iowa	A. Hine, A. L. Connable, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....
17	Jno. McCune, Keokuk, Iowa.....	J. Madden, H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....

*Lowest for cement.

Abstract of proposals received at the United States engineer office at Keokuk, Iowa, April 15, 1868, for materials and labor, &c.—Continued.

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 1.—Stone.								
				Face stone, 3,530 cubic yards.		Backing stone, 6,912 cubic yds.		Rubble stone, for vertical or battered wall, 8,850 cubic yards.		Rubble stone, for slope wall, 900 cubic yards.		Aggregate.
				Rate.		*Rate.*		*Rate.*		*Rate.*		
1	C. G. Case & Co., Fulton, N. Y.	W. Johnson, S. F. Case, Fulton, N. Y.	O. L. Wetmore	$7 00	$24,710 00	$5 00	$34,560 00	$5 00	$44,250 00	$1 25	$1,125 00	$104,645 00
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick, J. B. Baughman, Keokuk.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	R. M. McClaughry & Co., Keokuk, Iowa.	A. L. Connable, G. B. Smythe, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	10 00	35,300 00	7 00	48,384 00	6 00	53,100 00	3 00	2,700 00	139,484 00
4	Chas. E. Tobie, Utica, N. Y.	P. Tobie, J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	6 90	24,357 00	4 25	29,376 00	4 25	37,612 50	2 50	2,250 00	*93,595 50
5	E. Owen, Albany, N. Y. ..	J. S. McDonald, P. V. Fort, Albany, N. Y.	J. Davis, postmaster, Albany, N. Y.	7 00	24,710 00	5 00	34,560 00	4 00	35,400 00	1 50	1,350 00	96,020 00
6	C. and J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	Barnard & Gowen, Chicago, Ill.	C. L. Woodman, J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	9 00	31,770 00	7 00	48,380 00	6 00	53,100 00	5 00	4,500 00	137,754 00
8	Leddie & Corse, Chicago, Ill.	O. Fitzsimons, J. H. Mallery, Chicago, Ill.	F. Myers, deputy quartermaster general U. S. Army.	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	Brown, Bandon, & Co., Dayton, Ohio.	S. N. Brown, F. B. Stevenson, Dayton, Ohio.	T. J. Wood, brevet major general U. S. Army.	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	M. M. Rhorer, Louisville, Ky.	J. F. Speed, W. H. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	T. C. Clark, Quincy, Ill....	G. B. Dimmock, C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	R. Nelson Gere, Syracuse, N. Y.	E. B. Van Duzen, N. S. Gere, Geddes, N. Y.	H. Manger, postmaster.....	7 00	24,710 00	6 50	44,928 00	5 00	44,250 00	2 00	1,800 00	115,688 00
13	Jno. Loler, St. Louis, Mo..	G. A. Fillay, J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	10 00	35,300 00	7 00	48,384 00	7 00	69,950 00	4 00	3,600 00	149,234 00
14	Jas. Clark, Utica, Ill.....	Barnard & Gowen, Chicago, Ill.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	J. H. Mallery, Lemont, Ill..	Ledlie & Corse, Chicago, Ill.	F. Myers, deputy quartermaster general U. S. Army.	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	Jno. Napier, Keokuk, Iowa	A. Hine, A. L. Connable, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	Jno. McCune, Keokuk, Iowa.	J. Madden, H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	8 75	30,887 50	7 40	51,148 80	7 40	65,490 00	2 50	2,250 00	149,776 30

* Lowest for stone.

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 2.—Iron.				Class No. 3.—Lumber.				
				Wrought-iron, 10,000 pounds.		Cast-iron, 4,000 pounds.	Aggreg'te.	White oak timber, 60,000 feet, board measure.		White pine or hemlock, 150,000 feet, board measure.		Aggregate.
				Rate.		*Rate.*		*Rate.*		*Rate.*		
1	C. G. Case & Co., Fulton, N. Y.	W. Johnson, S. F. Case, Fulton, N. Y.	O. L. Wetmore	$0 13	$1,300 00	$0 10	$400 00	$1,700 00	$80 00	$4,800 00	$50 00	$7,500 00	$12,300
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick, J. B. Baughman, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	9	900 00	7	280 00	1,180 00	.....	.....	.....	.....	.....
3	R. M. McClaughry & Co., Keokuk, Iowa.	A. L. Connable, G. B. Smythe, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	Chas. E. Tobie, Utica, N. Y.	P. Tobie, J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	8	800 00	9	360 00	*1,160 00	.....	.....	.....	.....	.....
5	E. Owen, Albany, N. Y....	J. S. McDonald, P. V. Fort, Albany, N. Y.	J. Davis, postmaster, Albany, N. Y.	.....	.....	.....	.....	.....	75 00	4,500 00	40 00	6,000 00	10,500
6	C. and J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.	.....	12	1,200 00	13	520 00	1,720 00	.....	.....	.....	.....	.....
7	Barnard & Gowen, Chicago, Ill,	C. L. Woodman, J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	15	1,500 00	12	480 00	1,980 00	100 00	6,000 00	80 00	12,000 00	18,000
8	Ledlie & Corse, Chicago, Ill.	O. Fitzsimons, J. H. Mallery, Chicago, Ill.	F. Myers, deputy quartermaster general U. S. A.	.....	.....	.....	.....	.....	64 90	3,894 00	48 90	7,335 00	11,200
9	Brown, Bandon & Co., Dayton, Ohio.	S. N. Brown, F. B. Stevenson, Dayton, Ohio.	T. J. Wood, brevet major general U. S. Army.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	M. M. Rhorer, Louisville, Ky.	J. F. Speed, W. H. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	T. C. Clark, Quincy, Ill....	G. B. Dimmock, C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	R. Nelson Gere, Syracuse, N. Y.	E. B. Van Dusen, N. S. Gere, Geddes, N. Y.	H. Manger, postmaster.....	11¾	1,175 00	9	360 00	1,535 00	35 00	2,100,00	35 00	5,950 00	17,350
13	Jno. Loler, St. Louis, Mo ..	G. A. Fillay, J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	Jas. Clark, Utica, Ill	Barnard & Gowen, Chicago, Ill.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	J. H. Mallery, Lemont, Ill..	Ledlie & Corse, Chicago, Ill.	F. Myers, deputy quartermaster general U. S. A.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	Jno. Napier, Keokuk, Iowa	A. Hine, A. L. Connable, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	Jno. McCune, Keokuk, Iowa.	J. Madden, H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

* Lowest for iron. † Lowest for lumber.

Abstract of proposals received at the United States engineer office at Keokuk, Iowa, April 15, 1868, *for materials and labor, &c.*—Continued.

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 4.—Labor.								
				Bailing and draining.	Earth excavation, 2,000 cubic yards.		Rock excavation, 14,000 cubic yards.		Earth embankment, 110,000 cubic yards.		Lining, 6,000 cubic yards.	
					Rate.		*Rate.*		*Rate.*		*Rate.*	
1	C. G. Case & Co., Fulton, N. Y.	W. Johnson, S. F. Case, Fulton, N. Y.	O. L. Wetmore	$25,000 00	$0 40	$800 00	$4 00	$56,000 00	$0 65	$71,500 00	$1 65	$3,900 00
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick, J. B. Baughman, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.									
3	R. M. McClaughry & Co., Keokuk, Iowa.	A. L. Connable, G. B. Smythe, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.									
4	Chas. E. Tobie, Utica, N. Y.	P. Tobie, J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	87,170 00	30	600 00	1 75	24,500 00	75	82,500 00	75	4,500 00
5	E. Owen, Albany, N. Y....	J. S. McDonald, P. V. Fort, Albany, N. Y.	J. Davis, postmaster, Albany, N. Y.	20,000 00	50	1,000 00	4 00	56,000 00	55	60,500 00	75	4,500 00
6	C. and J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.										
7	Barnard & Gowen, Chicago, Ill.	C. L. Woodman, J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	75,000 00	70	1,400 00	3 00	42,000 00	70	77,000 00	1 50	9,000 00
8	Ledlie & Corse, Chicago, Ill.	O. Fitzsimons, J. H. Mallery, Chicago, Ill.	F. Myers, deputy quartermaster general U. S. A.									
9	Brown, Bandon & Co., Dayton, Ohio.	S. N. Brown, F. B. Stevenson, Dayton, Ohio.	T. J. Wood, brevet major general U. S. Army.	47,500 00	55	1,100 00	4 00	56,000 00	55	60,500 00	80	4,800 00
10	M. M. Rhorer, Louisville, Ky.	J. F. Speed, W. H. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.									
11	T. C. Clark, Quincy, Ill....	G. B. Dimmock, C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	30,000 00	35	700 00	1 75	24,500 00	35	38,500 00	1 00	6,000 00
12	R. Nelson Gere, Syracuse, N. Y.	E. B. Van Duzen, N. S. Gere, Geddes, N. Y.	H. Manger, postmaster.....	35,000 00	35	700 00	2 00	28,000 00	80	88,000 00	80	4,800 00
13	Jno. Loler, St. Louis, Mo...	G. A. Filley, J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.									
14	Jas. Clark, Utica, N. Y	Barnard & Gowen, Chicago, Ill.										
15	J. H. Mallery, Lemont, Ill	Ledlie & Corse, Chicago, Ill	F. Myers deputy quartermaster general U. S. A.	35,000 00	50	1,000 00	3 00	42,000 00	60	66,000 00	75	4,500 00
16	Jno. Napier, Keokuk, Iowa	A. Hine, A. L. Connable, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	30,000 00	45	900 00	2,75	38,500 00	60	66,000 00	1 00	6,000 00
17	Jno. McCune, Keokuk, Iowa.	J. Madden, H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector internal revenue.	45,000 00	75	1,500 00	3 50	49,000 00	55	60,500 00	1 00	6,000 00

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 4.—Labor.									
				Loose stone, 2,000 cubic yds.		Puddling, 5,000 cubic yds.		Constructing slope wall, 9,000 cubic yds.		Constructing vertical or battered wall, laid in cement, 6,000 cub. yds.		Construct'g vertical or battered wall, laid dry, 2,850 cub. yds.	
				Rate.		*Rate.*		*Rate.*		*Rate.*		*Rate.*	
1	C. G. Case & Co., Fulton, N. Y.	W. Johnson, S. F. Case, Fulton, N. Y.	O. L. Wetmore	$1 75	$3,500 00	$0 25	$1,250 00	$0 75	$675 00	$2 00	$12,000 00	$2 00	$5,700 00
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick, J. B. Baughman, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	R. M. McClaughry & Co., Keokuk, Iowa.	A. L. Connable, G. B. Smythe, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	Chas. E. Tobie, Utica, N. Y.	P. Tobie, J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	2 50	5,000 00	30	1,500 00	1 75	1,575 00	2 00	12,000 00	2 00	5,700 00
5	E. Owen, Albany, N. Y....	J. S. McDonald, P. V. Fort, Albany, N. Y.	J. Davis, postmaster, Albany, N. Y.	1 50	3,000 00	25	1,250 00	1 25	1,125 00	2 25	13,500 00	2 25	6,412 50
6	C. and J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	Barnard & Gowen, Chicago, Ill.	C. L. Woodman, J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	1 50	3,000 00	40	2,000 00	2 50	2,250 00	5 00	30,000 00	4 00	11,400 00
8	Ledlie & Corse, Chicago, Ill.	O. Fitzsimons, J. H. Mallery, Chicago, Ill.	F. Myers, deputy quartermaster general U. S. A.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	Brown, Bandon & Co., Dayton, Ohio.	S. N. Brown, F. B. Stevenson, Dayton, Ohio.	T. J. Wood, brevet major general U. S. Army.	1 00	2,000 00	25	1,200 00	2 50	2,250 00	6 50	39,000 00	4 00	11,400 00
10	M. M. Rhorer, Louisville, Ky.	J. F. Speed, W. H. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	T. C. Clark, Quincy, Ill....	G. B. Dimmock, C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	1 00	2,000 00	1 00	5,000 00	3 00	2,700 00	5 00	30,000 00	5 00	14,250 00
12	R. Nelson Gere, Syracuse, N. Y.	E. B. Van Dusen, N. S. Gere, Geddes, N. Y.	H. Manger, postmaster.....	80	1,600 00	20	1,000 00	1 00	900 00	4 00	24,000 00	3 50	9,975 00
13	Jno. Loler, St. Louis, Mo ..	G. A. Fillay, J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	Jas. Clark, Utica, Ill.....	Barnard & Gowen, Chicago, Ill.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	J. H. Mallery, Lemont, Ill.	Ledlie & Corse, Chicago, Ill.	F. Myers, deputy quartermaster general U. S. A.	1 50	3,000 00	25	1,250 00	1 00	900 00	3 00	18,000 00	3 00	8,550 00
16	Jno. Napier, Keokuk, Iowa	A. Hine, A. L. Connable, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	1 00	2,000 00	40	2,000 00	1 50	1,350 00	4 75	28,500 00	3 25	9,262 50
17	Jno. McCune, Keokuk, Iowa.	J. Madden, H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	1 60	3,200 00	1 25	6,250 00	1 00	900 00	3 50	21,000 00	3 00	8,550 00

Abstract of proposals received at the United States engineer office at Keokuk, Iowa, April 15, 1868, for materials and labor, &c.—Continued.

No. of proposal.	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Class No. 4.—Labor.									
				Concrete masonry, 500 cubic yards.		Construct'g masonry in lock walls, 10,442 cubic yards.		White oak timber, preparing, dressing, and putting into work 60 000 feet b'rd measure.		White pine or hemlock, prepuring, dressing, and putting into work 150,000 feet b. m.		Wrought-iron, handling and putting in, 10,000 lbs.	
				Rate.		*Rate.*		*Rate.*		*Rate.*		*Rate.*	
1	C. G. Case & Co., Fulton, N. Y.	W. Johnson, F. S. Case, Fulton, N. Y.	O. L. Wetmore	$6 00	$3,000 00	$7 50	$78,315 00	$35 00	$2,100 00	$15 00	$2,250 00	$0 06	$600 00
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick, J. B Baughman, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	R. M. McClaughry & Co., Keokuk, Iowa.	A. L. Connable, G. B. Smythe, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	Chas E. Tobie, Utica, N. Y.	P. Tobie, J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	10 00	5,000 00	6 22	64,949 24	15 00	900 00	15 00	2,250 00	05	500 00
5	E. Owen, Albany, N. Y...	J. S. McDonald, P. V. Fort, Albany, N. Y.	J. Davis, postmaster, Albany, N. Y.	5 00	2,500 00	7 00	73,094 00	40 00	2,400 00	20 00	3,000 00	8	800 00
6	C. and J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	Barnard & Gowen, Chicago, Ill.	C. L. Woodman, J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster Chicago, Ill.	5 00	2,500 00	10 00	104,420 00	15 00	900 00	10 00	1,500 00	04	400 00
8	Ledlie & Corse, Chicago, Ill.	O. Fitzsimons, J. H. Mallery, Chic go, Ill.	F. Myers, deputy quartermaster general U. S. A.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	Brown, Bandon & Co., Dayton, Ohio.	S. N. Brown, F. B. Stevenson, Dayton, Ohio.	T. J. Wood, brevet major general U. S. Army.	7 00	3,500 00	12 50	130,525 00	80 00	4,800 00	50 00	7,500 00	15	1,500 00
10	M. M. Rhorer, Louisville, Ky.	J. F. Speed, W. H. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	T. C. Clark, Quincy, Ill ..	G. B. Dimmock, C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	6 00	3,000 00	10 25	107,030 50	30 00	1,800 00	27 00	4,050 00	05	500 00
12	R. Nelson Gere, Syracuse, N. Y.	E. B. Van Dusen, N. S. Gere, Geddes, N. Y.	H. Manger, postmaster.....	5 00	2,500 00	9 00	93,978 00	10 00	600 00	10 00	1,500 00	10	1,000 00
13	Jno. Loler, St. Louis, Mo..	G. A. Fillay, J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	Jas. Clark, Utica, Ill.....	Barnard & Gowen, Chicago, Ill.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	J. H. Mallery, Lemont, Ill.	Ledlie & Corse, Chicago, Ill.	F. Myers, deputy quartermaster general U. S. A.	3 50	1,750 00	9 75	101,809 50	15 00	900 00	10 00	1,500 00	10	1,000 00
16	Jno. Napier, Keokuk, Iowa.	A. Hine, A. L. Connable, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	6 00	3,000 00	9 00	93,978 00	20 00	1,200 00	10 00	1,500 00	12	1,200 00
17	Jno. McCune, Keokuk, Iowa.	J. Madden H W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	2 50	1,250 00	8 00	83,536 00	5 00	300 00	5 00	750 00	.....	.....

No. of proposal	Name and residence of bidder.	Name and residence of guarantor.	Certified to by—	Cast-iron, handling and putting in, 4,000 pounds.		Wrought spikes and nails, handling, &c., 4,000 pounds.		Lead and antimony, 500 lbs.		Sulphur and sand for cement.		Aggregate	Grand aggregate.
				Rate.		Rate.		Rate.		Rate.			
1	C. G. Case & Co., Fulton, N. Y.	W. Johnson, S. F. Case, Fulton, N. Y.	O. L. Wetmore	$0 05	$200 00	$0 12	$480 00	$0 25	$125 00	$500 00	$500 00	$267, 895 00	$403,280 00
2	M. Sellers & Co., Keokuk, Iowa.	R. S. Ruddick, J. B. Baughman, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	R. M. McClaughry, & Co., Keokuk, Iowa.	A. L. Connable, G. B. Smythe, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	Chas. E. Tobie, Utica, N. Y.	P. Tobie, J. F. Kerrigan, Utica, N. Y.	L. Blakeslee, United States collector.	05	160 00	03	120 00	10	50 00	100 00	100 00	299, 074 24	.....
5	E. Owen, Albany, N. Y.	J. S. McDonald, P. V. Fort, Albany, N. Y.	J. Davis, postmaster, Albany, N. Y.	06	240 00	12	480 00	20	100 00	500 00	500 00	250, 401 50	.....
6	C. and J. Cooper, Mount Vernon, Ohio.	G. A. Jones, Mount Vernon, Ohio.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	Barnard & Gowen, Chicago, Ill.	C. L. Woodman, J. M. Drake, Chicago, Ill.	F. J. Sherman, postmaster, Chicago, Ill.	04	160 00	10	400 00	25	125 00	200 00	200 00	364, 155 00	544,083 00
8	Ledlie & Corse, Chicago, Ill.	O. Fitz-simons, J. H. Mallery, Chicago, Ill.	F. Myers, deputy quartermaster general U. S. A.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	Brown, Bandon & Co., Dayton, Ohio.	S. N. Brown, F. B. Stevenson, Dayton, Ohio.	T. J. Wood, brevet major general U. S. Army.	10	400 00	10	400 00	.....	(No bid.)	.....	.....	374, 425 00	.....
10	M. M. Rhorer, Louisville, Ky.	J. F. Speed, W. H. Henning, Louisville, Ky.	P. Speed, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	T. C. Clark, Quincy, Ill.	G. B. Dimmock, C. E. Allen, Quincy, Ill.	J. Grisham, collector of internal revenue.	10	400 00	10	400 00	1 00	500 00	.....	(No bid.)	271, 330 50	.....
12	R. Nelson Gere, Syracuse, N. Y.	E. B. Van Dusen, N. S. Gere, Geddes, N. Y.	H. Manger, postmaster	10	400 00	10	400 00	30	150 00	500 00	500 00	295, 003 00	435,116 00
13	Jno. Loler, St. Louis, Mo.	G. A. Fillay, J. W. Bell, St. Louis, Mo.	L. M. Breckenridge, acting collector.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	Jas. Clark, Utica, Ill.	Barnard & Gowen, Chicago, Ill.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	J. H. Mallery, Lemont, Ill.	Ledlie & Corse, Chicago, Ill.	F. Myers, deputy quartermaster general U. S. A.	05	200 00	05	200 00	75	375 00	500 00	500 00	288, 434 50	.....
16	Jno. Napier, Keokuk, Iowa.	A. Hine, A. L. Connable, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	12	480 00	12	480 00	25	125 00	100 00	100 00	286, 575 50	.....
17	Jno. McCune, Keokuk, Iowa.	J. Madden, H. W. Sample, Keokuk, Iowa.	W. W. Belknap, collector of internal revenue.	.....	.....	.....	.....	.....	.....	.....	.....	287, 736 00	.....

* Lowest for labor.

J. H. WILSON, *Lieut. Col. 35th Inf., Bvt. Maj. Gen. U. S. A.*

UNITED STATES ENGINEER OFFICE, *Keokuk, Iowa, August* 18, 1868.

H 6.—*Abstract of contracts made on account of the improvement of the Des Moines rapids of the Mississippi river, during the fiscal year ending June 30, 1868.*

No.	Names of contractors.	Residence.	Date of contract.	Nature of contract.	Price.
1	Wm. Henegan & Jno. Henegan.	Mt. Vernon and Ravenna, Ohio.	Sept. 25, 1867	Grubbing and cleaning	$200 00
				Bailing and drainings	2,500 00
				Earth excavation ..... per cubic yard...	33
				Rock excavation..... do	1 35
				Embankment..... do	37
				Lining ..... do	40
				Labor of puddling ..... do	20
				Loose stone in riprap walls, &c..... do	1 35
				Slope wall..... do	2 00
				Vertical or battered rubble wall, laid in hydraulic cement, per cubic yard.....	5 25
				Vertical or battered rubble wall, laid dry...per cubic yard..	4 50
				Concrete masonry..... do.....	5 25
				Constructing the public road, including the necessary bridges and abutments..... per rod..	2 25
				Changing railroad track, including bridges and abutments, per mile	500 00

J. H. WILSON,
Lieut. Col. 35th Infantry, Brevet Major Gen. U. S. A.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, August 18, 1868.

UNITED STATES ENGINEER OFFICE,
Davenport, July 20, 1868.

GENERAL: I have the honor to submit the following report of the operations for the improvement of the Rock Island rapids of the Mississippi river, for the year ending June 30, 1868.

In accordance with Engineer Orders No. 104, of October 7, 1867, relieving me from duty with Colonel Blunt, at Oswego, New York, and ordering me to report to you, I proceeded to this place, reporting for duty on the 30th of the same month.

I received verbal instructions from you to assume local charge of the improvements of the Rock Island rapids, and proceeded to make an inspection of the work.

Prior to my arrival here the main portion of the surveys of the rapids had been made by Lieutenant E. F. Hoffman, and numerous and very correct soundings been obtained by him.

The parties had returned from the field, and were engaged in copying and reducing field-notes and soundings preparatory to plotting them for use.

This survey had been very carefully and systematically made, and recent trials have demonstrated its perfect accuracy.

The nature and extent of the improvement had already been decided by you, based upon the results of surveys and reconnoissances in the fall of 1866, and contemplated the removal of the rock-bed of the river at the various shoal places, or chains, so as to give, at lowest stage of water known, a continuous channel at least four feet in depth and 200 feet in width. The surveys made during the summer of 1867 were intended to replace those made in the preceding year, the latter not being sufficiently minute for working purposes.

The contractors had commenced the first work of the season, under their contract, by putting in position a coffer-dam on Duck Creek chain, about six miles above this place, and one of the most difficult obstacles to be overcome at low water, by steamers of from three to four feet draught.

This dam had been located by Colonel Hains, without the use of instruments, the soundings not having been then plotted; and, although based mainly by the eye, later experience shows it to have been advantageously placed, and in nearly the same position that would have been assigned to it with the full knowledge of the shape of the bottom and extent of the shoal, afterwards obtained by plotting the soundings. The current over this chain approached four feet per second, with a surface slope of 0'.33-1,900. The possibility of constructing a coffer-work, at anything like a reasonable expenditure, was a matter of doubt in the minds of the contractors.

This dam was commenced on the 8th of September, and finished by the 15th of October following. Its distance from the Iowa shore was about 1,000 feet, and from the head of Rock island about two and a half miles. It had a development of 1,310 linear feet, viz: Up-stream face, 503 feet 10 inches; down-stream (or lower) face, 203 feet; north face, 100 feet 6 inches; south face, 481 feet; the upper and lower faces being built eight feet in thickness and the sides six feet in thickness.

The contract was drawn up the 28th of June preceding, but, in addition to the delays necessary in procuring materials and machinery, it was thought necessary to delay for the low stage of water which usually occurs in September. The gauge showed on the 8th nine feet of water above the zero of the scale, viz: the plane of lowest water of 1864, and on the 15th of October it showed one foot ten inches. The mean depth

of water on the dam was four feet six inches. Total area inclosed by the dam, about 86,000 square feet. The cost of dam was $7,500.

For a more detailed report of the method of putting in this work, as well as description of same, I would refer you to the appended report of J. P. Frizell, civil engineer and assistant upon the work.

For clearing the area of water a centrifugal pump (Sisson's patent, I think) of eight horse-power was employed. It was located at the southwest angle of the dam, the depth of water being there the greatest. While clearing the area it discharged at the rate of 197.5 cubic feet per minute, raising the water from six to seven feet; 39 hours in all were consumed in removing the water. The cost of this pump was $1,300. The area having been cleared, lines of levels were run, both longitudinally and transversely; the lines being 10 feet apart, and the references of their points of intersection taken. These were to be compared with the levels to be taken after the completion of the work. In addition to the area inclosed by the dam, and requiring excavation, small isolated patches of rock existed, both above and below, of too small area to be inclosed by a coffer. These were to be removed by chisels. These latter are of wrought iron, about nine feet in length, weighing 5,800 pounds, and steel-pointed. They work in guides, similar to those of a pile-driver, and are raised by steam. They have a fall of about seven feet. The boats upon which the chisels and machinery are placed are about 60 feet in length, and shaped like the usual dredge-boat. The broken rock is raised by dredging.

On the 26th of November I received the following order, viz:

UNITED STATES ENGINEER OFFICE,
Davenport, November 26, 1867.

I. Brevet Major Charles J. Allen, captain of engineers, is assigned to duty as senior assistant, and in local charge of the improvements of the Rock Island rapids. He will superintend the labor of the contractors, keeping ample notes of their daily operations, and supervising the estimates of work done. He will also exercise a general supervision over the completion of the maps projected by Lieutenant Hoffman, and will have a supervising charge over the mapping and draughting done at this office.

* * * * * * * * *

J. H. WILSON,
Lieutenant Colonel 35th Infantry, Brevet Major General U. S. Army.

At this time the work was progressing well in the dam. The contractors had a good force of men employed in quarrying, and had also the following boats and dumps:

One steamer, at a cost of	$6,000
Two chisel-boats, each $9,000	18,000
One dredge	21,500
Two dumps, $400 each	800
Five flats, $600 each	3,000
	50,300

The work of quarrying commenced on the 22d of October, and continued without interruption until the 20th of December. The quarrying was performed by means of the ordinary hand-drill and blasting powder. A steam-drill of Gardner's patent was tried, but failed to perform satisfactory work. The rock-bed of the bottom was a common limestone, of the Diomion formation, irregularly stratified, gnarled and twisted, and filled with pebbles and geodes. This made the work of blasting much more difficult than it would have been otherwise, it being almost impossible to proportion the charges to produce certain results.

The effects of the blasts were very unequal, and the depth could not be controlled, as would have been the case in a rock of regular strata. The specific gravity of this rock varied from 2.3 to 2.7. The drills used varied in diameter from one and a half inch to two and a half inches, and the depth of hole (magazine) from one and a half foot to four feet. To avoid the effect of moisture in the rock, and to form a water-tight magazine, the holes drilled were pumped out, or rather sponged out, and partially filled up with soft pliable clay; the drill was then forced down again into this clay, forcing it against the sides, making a water-tight lining.

Experience proved that the proportion of rock excavated to that of powder used was seven-thirteenths yard of the rock to one pound of powder; fine sand and pulverized rock used for tamping. From six to twenty mines were generally exploded simultaneously.

The expediency of using nitro-glycerine was discussed, but this material was finally rejected; as, from its suddenness of explosion and great power, it could not have been under sufficient control. Its explosive force, as compared with blasting powder, is asserted to be 13, that of powder being unity. Its "tearing properties" would have rendered destructive to the coffer-work if used in very close proximity to it. I regret that the opportunity of witnessing its effects was denied me.

The season was unusually favorable for working; by the 20th of December the ice had formed so rapidly in the vicinity of the dam that operations were suspended, for the reason that the excavated rock could not be moved in boats. The rock in the interior of the dam had been excavated to the required depth, and water was let in. The chisel-boats, barge, &c., were moored below the dam, the contractors regarding this the safest position, the coffer serving as an ice-breaker.

The total quantity of rock removed up to the time of closing work was 7,000 cubic yards, of which 5,184 cubic yards were taken from the inside of the dam, and the remainder broken by the chisels and dredged up. Part of this amount was returned to the river, being deposited in the holes or pockets. This was a sort of compensation, and kept the available area of cross-section about the same as before. Such of the rock as was not disposed of in this manner was deposited upon the government dam at the head of Rock island, and in cribs provided by the Commerce department for the extension of the same. About 2,000 yards of rock were disposed of in this manner. During the winter the assistants and draughtsman were employed in mapping and plotting, and getting up working sheets for the next season's work.

Upon the breaking up of the ice, which occurred in March, the contractors experienced considerable loss from damage done to their boats by the floating ice, and considerable delay ensued in placing them again in condition for work.

The copious rains caused a simultaneous movement of the ice throughout the long extent of the river; and as it moved it gorged at various points, causing a rise of water above each point, and a consequent inundation of lands. As early as January I warned the contractors of the danger to their boats, and advised them to remove them to some more sheltered position. I stated to them that the river would undoubtedly rise to a height above the top of their dam, and that then the ice would begin to move over it and collide with their boats. The ice had generally broken up from below, each field as it moved leaving a space free from the field of ice above it. This year it seemed to break up simultaneously, and the whole mass moved. The chisel-boats were carried down stream for about four miles. They were severely racked, and required new

plank, timber, and some parts of the machinery renewed. That they were not totally destroyed is due to the fact that they moved with the ice. Some idea of the freshet may be obtained, when we consider the statement that the water rose eight feet in two hours, and upon the gorge giving way below, it fell five feet in as many minutes. This last gorge was about three-fourths of a mile below the railroad bridge; and to this sudden fall I attribute the destruction of the bridge and its piers. One of these piers was moved laterally 16 feet from its position, deflected considerably from the vertical, and racked so as to render the building of a new one necessary.

Work was resumed at Duck creek by the chisel-boats and dredge on the 21st of April. The total amount of rock excavated and removed, up to the 30th of June, is 6,898 yards, as per following statement:

	Yards.
October, 1867	544.52
November, 1867	2,559.29
December, 1867	2,404.68
April, 1868	42.00
May, 1868	475.91
June, 1868	574.26
Total	6,600.66

To this add 298 yards excavated by the contractors for crib-filling, and the total reaches 6,898.66 yards. Of this 1,714.86 yards were removed by the chisels and dredge.

The contract contemplated the payment for the solid contents of rock as it existed in the bed. This estimate could be easily arrived at by a comparison of the levels taken before and after excavation. For monthly or partial payments, the solid contents were obtained by the method of displacement; the amount of water displaced by each flat before being loaded was obtained; the flat then being filled with stone to any extent, the difference of cubic feet displaced by the boat free and the boat loaded gave the number of cubic feet displaced by the stone alone; this, divided by the specific gravity of the rock, gave the number of cubic feet of rock in the flat. This method gave very accurate results, as proved by several tests. Various specimens of rock were taken, their specific gravities found, and an average density decided upon.

It was claimed by the contractors that they had moved more rock by their chisels from the area above the dam, than was allowed them by this measurement. They asserted that most of the rock was pulverized by their chisels, and swept away by the current, and consequently not contained in the measurements. This I regarded as quite probable, though not to the extent that they claimed. Examination of the dredging showed that much of what they took up was very finely broken and pulverized, and very likely to be swept or scoured by the under-current. Dubuat states, as the result of his observations, that beds of streams, composed of pebbles of one and one-half inch in diameter, will resist the action of a current not exceeding 3.33 feet per second. As the current at this point exceeded the above figures, and much of the stone broken was very much smaller than the example given, I had no doubt of the correctness of the claim.

Further examinations showed that the deep holes or pockets in the immediate vicinity of the places chiseled were filled with pieces of loose rock of various sizes. These had, undoubtedly, slid off under the

action of the chisels and not been counted in the measurement. Numerous soundings made over this area showed that the obstructions had all been removed. By multiplying the areas of the places worked over by the depth of cutting assumed from the charts, an estimate was arrived at for this portion of the work which was satisfactory. Upon the area below the dam, and protected by the latter from the current, the measurements by displacement were found to tally very closely with those obtained by soundings. Much finely pulverized rock is here dredged up, the great force of the current being broken by the obstructions above.

The terms of contract required the removal of 5,000 yards of rock per month during the working season. This rate has not been approached as yet, owing to various unforeseen difficulties.

I did not feel satisfied with the amount of work performed, nor do I think that enough hands were employed at any one time. For work of this description, where the drilling is done by hand and the rock removed in barrows, the apportionment of men should be one to every 200 square feet inclosed by the dam; this includes foremen, blacksmiths, engineers, quarrymen, laborers, &c. The following is an exhibit of labor for the month of November, 1867, and will serve as a specimen of the whole:

Number of days' service spent in drilling	1,200
Number of days' service spent in quarrying	960
Number of days' service spent in dumping	240
Number of days' service spent in chiseling, (men)	286
Number of days' service spent in dredging, (men)	130
Number of days' service spent in pumping	120
Number of days' service of steamboat crew	150
Number of days' service of blacksmith	60
Number of days' service of foremen	286
Number of days' service of supplymen	56
Number of days' service of superintendents	90
Total days' work	3,578

This gives an average of 138 men employed daily for a month of 26 working days.

Number of feet of 2½-inch holes drilled with striking-drills	4,608
Number of feet of 2½-inch holes drilled with churn-drills	4,992
Total of linear feet	9,600
Number of pounds of powder expended	4,250
Number of feet of fuse	1,200

Area worked over by the chisel-boats, about 22,000 square feet. Depth of cutting, about 1 foot 6 inches. The chisels when worked steadily can make from 1,500 to 2,000 strokes per day.

It having been decided to commence work this year on Moline, Sycamore, and Campbell's chains, if possible, the maps and working sheets pertaining to these chains were plotted and careful examinations made to determine the lines of least cutting on each, and at the same time to get easy curves and place the axes of the cuts as nearly as possible to coincide with the direction of the currents.

The directions of currents and their velocities were determined by actual observation and placed upon their respective sheets. Levels were

run from foot to head of the rapids, on either shore, connecting above and below, and low-water bench marks established opposite each chain for ready reference.

The buoys for the coffer-dam at Moline chain were placed early in June of this year, the line of excavation having been decided upon by you. This chain presented many difficulties to the establishment of a dam, on account of the great velocity which here obtains. The current above this chain has a velocity of 3.63 feet per second; upon that portion requiring a coffer, 6.36 feet per second, and below it nearly 4 feet per second; the surface slope being .37 of a foot upon 900.

The buoys were laid out by the theodolite, from the primary sounding base on the Iowa shore, the angles being computed from the known sides of the triangles. Cribs were sunk and a bulkhead formed as in the construction of the dam at Duck creek.

A greater thickness of puddling was considered necessary, the up and down stream faces being each ten feet in thickness, and the sides eight feet; otherwise the construction does not differ materially from that at Duck creek. About 250 lineal feet of this work is completed. The dam will be 250 feet in width, and its sides respectively about 900 and 1,100 feet. Its axis will make an angle of about 26° with the direction of the current at high water, and will coincide nearly in direction with the surface current at lowest water. For a discussion of the points involved I would refer you to my letter of May 4th. The dam will be cleared by pumping, as at Duck creek, but more slowly, as the experience of last year proved that quick pumping was a disadvantage, the puddling settling unevenly upon a sudden withdrawal of the water.

The portion of the chain below the dam will be worked with the chisels.

The contractors have had an increased number of boats, and the prospect is that the ensuing year will witness a full amount of work on their part.

They have now 2 dredges, 11 scows, 2 steamers, 2 chisel-boats, and 2 dump-boats.

It is proposed to commence work at Sycamore chain during the month of July ensuing, and to begin at Campbell's chain as soon thereafter as possible.

Duck Creek chain will probably be finished also the next month, and the dam removed. Assistants have been engaged during the spring in supervising the work at the various chains, in mapping and plotting, and in making such surveys as were found necessary from time to time in the furtherance of the work.

Water-gauges were established early in 1867, fourteen in number, their readings recorded twice a day, and plotted. These I reduced in November to four, and subsequently removed them all, except one retained at this place.

The nearest government work is the Rock Island arsenal.

Thus far the work has been very interesting and instructive, and its practicability of execution fully demonstrated.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers and Brevet Major.

Brevet Major General J. H. WILSON,
Lieutenant Colonel 35th Infantry, Keokuk, Iowa.

H 8.

UNITED STATES ENGINEER OFFICE,
Davenport, Iowa, July 20, 1868.

MAJOR: I have the honor to submit the following report of operations for the year ending June 30, 1868, for the improvement of the Rock Island rapids, as requested in your official letter of June 15, 1868.

In the spring of 1867 I was ordered to resurvey the Rock Island rapids. The appropriation by Congress had been made to improve these rapids, and it was considered necessary by General Wilson to sound each chain in a more thorough manner than it could have been done in the short time which was allowed the engineers in the fall of 1866.

I commenced the resurvey May 29, 1867, and finished the same July 5, 1867, a total of 38 days; of these, six were Sundays, or holidays, leaving but 27 actual working days.

Two lines were run by theodolites, one on the Illinois, and the other on the Iowa side of the river, from the railroad bridge at Davenport to the town of Le Claire. The Iowa line contains 58 stations, and the Illinois line 62; my total number of stations being 85 less than were used in the fall survey of 1866. Every station is marked by a pointed stake, those on the Iowa shore being numbered, while those on the Illinois shore are lettered. All base lines were lined in with the theodolite and twice chained. The triangulation rests upon 50 separate bases. The maximum error of observation was fixed at two minutes, but in most of the triangles the difference is but one minute. One-third of the whole number of angles in the triangles amounting exactly to 180°. The accuracy of the work may be judged when it is said that an error of one minute in a triangle, whose base line is 2,000 feet, would cause an error of only four-tenths of a foot in the sides of the triangle.

After shore lines were run for each chain on the rapids, a separate base line was laid out, from which the observation of soundings could be taken. These base lines were laid out with the greatest care, and connected with the trigonometrical net of the survey. Each one extends from the head to the foot of the chain, and its length not less than 3,000 feet. This was necessary for the purpose of getting in the observation of soundings, no bearings being over 90°. At Lower chain, Moline, Duck creek, Sycamore, and Smith's chains, these base lines are in one straight line; at Campbell's chain the base line is broken, and makes in itself a triangle, two sides of which were carefully measured, and the third side calculated. It appeared necessary to have three theodolites on each of these base lines when sounding the chains, so as to be able to substitute one instrument for another in case of accident, or in case one observer should have missed one of the bearings. Then, in order to bring the two parts of the base line in exact harmony from each theodolite point, a point on the opposite shore was triangulated, and each angle was observed at each instrument 25 times. By this system, which I called "correction for base lines," the two parts of the base line were brought in perfect harmony.

In the measuring of these base lines a very broad steel tape line was used, and the measuring always gone over with the second time; in consequence, the actually measured base line with the corrected base line by triangulation gave very little difference; for instance, at Smith's chain it was not more than three-tenths of a foot. These points at the base line, where theodolites had been stationed, were marked by good, large-sized quarried stones, so that in the working of the different

chains these stations can always be relied on, as they are known to be correct and accurate.

In the meantime a new level was run on both sides of the river. The first line commenced at the railroad bridge at Davenport, and ran to Le Claire, a distance of 14 miles. At this place I leveled, via Barber's island, to the opposite side of the river, (the Illinois river,) and leveling down to the bridge and connecting there with the bench from which I had started, a difference of but 0.255 foot was found. Considering the whole length of 28 miles run, and the transfer of levels from one side of the river to the other, the result, considering accuracy, was more than satisfactory. In high stage of water the fall of the river from Le Claire to the bridge at Davenport is 17.11 feet, and in low stages of water 18.43 feet. Good reliable bench-marks were established along the river, and this number augmented in the spring of this year, so that now at the head and at the foot of each chain a bench-mark is established from which levels can be taken over to the coffer-dams, where such shall exist, or to the point where excavation is to be carried on by the chisel-boats. In this preparatory work, before sounding the different chains, the establishment of water-gauges was made, for the purpose of noting the effect one chain had upon the others during a rise or fall of the river. These water-gauges, 14 in number, were placed on the important chains, and during a period of ten months were observed and the result recorded twice daily. From the plotted curves, thus obtained, it was possible to judge very closely as to the low-water mark of 1864, even at such places where, notwithstanding diligent search, no reliable low-water mark could be obtained from river pilots or residents living near the chain. In the month of August and September the work of sounding the different chains was carried into effect. To obtain a great number of soundings in a short space of time, a peculiar plan or system of my own was adopted, which, so far as I know, was never before attempted in the survey or sounding of any river. A small light-draught steamer (the Le Claire) of about one foot eight inches draught was chartered, and to each side of the steamer three skiffs were attached by a kind of bridge, having an interval of 12 feet between each skiff, as shown in accompanying sketch, marked Fig. 2. The whole width of this sounding apparatus was 90 feet. Behind the pilot-house on the steamer a double flag-staff, 24 feet in height, and in line with the skiffs, was erected, to which were attached two flags, one red and the other white, with counter weights attached, as shown in Fig. 3.

The chain to be sounded was marked out by buoys at the foot of the same, with an interval of 90 feet between each buoy, which corresponded with an equal number at the head of the chain. (See Fig. 4.)

The observers of theodolites stationed at the theodolite stand-points, the steamer entered the line of buoys at the foot of the chain, striking with the outside right-hand skiff the first buoy, and moving very slowly up stream. As soon as the watch in charge of the "timekeeper" indicated 15 seconds before a full minute, the white flag was hoisted half mast, which signified to the observers on shore, *attention*. They then clamped their instruments and followed the little jack-staff on the flag-staff with the tangent screw until at the full minute, which was marked by a loud whistle on board the steamer; the white flag then went up full mast, and the observers on shore recorded the degrees and minutes given; at the same moment, the eight sounders stationed in the skiffs and on board the steamer let drop perpendicularly their sounding poles of 15 feet in length, and communicated the respective depths of water to their recorders, who consisted entirely of boys, and were stationed one

sounder. An "observer of compass" was also stationed in kiffs; this observer had to take, at the moment the flags were the bearing which the line of skiffs was making, as indicated ass. He was also allowed a recorder, who wrote down either earings taken or the oscillation, of which the true bearings ards found.

tion.—The observers of theodolites fixed at the given signal he point of the flag-staff in reference to the base line. The f compass" fixed the direction of the line of skiffs, meaning of the soundings, in reference to the needle, and, finally, sounders took, at the given moment, the depth of the river eration was repeated each minute.

nistakes, the uneven numbers of bearings were signalized by g, the even numbers by the red. Besides the observations olites taken every minute from the shore, at each half minute dropped their poles upon a given signal, and took the depth observer of the compass taking in the mean time the bearing. gs were interpolated as given in sketch. (Fig. 6.)

ng of the steamer was so regulated that she was never allowed than about 30 or 40 feet per minute, so that generally at a line of eight soundings was taken. First the whole surface was run over by these parallel sounding trips, and if it was that the ground was not sufficiently covered with soundings, l trips were repeated until satisfactory results were obtained, if, on account of current, accident, or any other hinderance, round should have escaped and not been thoroughly sounded, ter completing the parallel trips, another mode, which I ag trips." In these trips the pilot was at liberty to go thought it advisable to sound again. He could run any ght proper, and was followed up by the instruments, as in parallel lines. (See Fig. 7.)

antity of soundings were in this manner quickly obtained, by the following statement:

were taken at—

.....	10,000
.....	16,000
hain.....	18,000
hain.....	19,000
ain.....	15,000
.....	14,000
ches.....	8,000
.....	100,000

hain is the only one not sounded, an order having been nd the steamer Le Claire to the Des Moines rapids, which is being accomplished.

ost of this kind of sounding, compared with the old method by means of a skiff, is very small. A sounding party, con- boatmen, one sounder, two observers of theodolites, three d a pilot and skiff, cost $26 50 per day. The cost of a rty, of the same size as the party engaged in taking the ngs, including charter of steamer and all other incidental ounted to $71 60 per day.

named party could with accuracy take from 500 to 600

soundings during the day, at a cost of about five cents for each sounding taken, while by my method 8,000 to 10,000 soundings were taken in the same length of time, at a cost of less than one cent per sounding.

It will be seen that the cost, comparing the old and new method, gives my plan an advantage of five to one, while, as regards rapidity, the proportion would be as 16 to 1 in favor of the method used.

NEW SYSTEM PER DAY.		OLD SYSTEM PER DAY.	
Steamer, including men and coal	$20 00	One skiff	$0 50
One pilot	5 00	One pilot	5 00
Two observers of theodolites	10 00	Two observers of theodolites	10 00
One observer of compass	2 50	Two boatmen	4 60
Eight sounders	18 40	One sounder	2 30
Twelve recorders	15 70	Three recorders	3 90
Total	71 60	Total	26 30

Another great superiority of the method adopted is the correctness with which these soundings were obtained; the whole apparatus moved slowly and steadily, and permitted accurate observations by the instruments on shore to be taken. In nearly all the observations taken, the cross-hair were exactly covering the jack-staff on the steamer. Finally, as regards cost, time, and reliability, this method must recommend itself. It has been thoroughly tested on the Rock Island rapids, and, in my estimation, should be employed where any large number of soundings are to be taken.

After having finished the field-work of the survey, I was charged with the plotting and mapping of the same. The meanderings of the river were calculated in reference to latitude and departure, and the triangulation computed. The bearings of theodolites were all calculated to minutes. It seemed prudent to do this, as the entire work was observed accurately to minutes. The use of the best minute protractor would have led to errors and mistakes, owing to the large number of soundings taken, and more especially on account of the large scale, and consequently large sheets of paper which I was compelled to use. The longest lever arm of an 8-inch protractor would have been too short and inaccurate to execute this work. I therefore proceeded to calculate each point of theodolite bearing in reference to the base line by abscissas and ordinates. To make this calculation simple and comprehensive, I converted the formula

$$a : b = \sin a : \sin \mathrm{B};$$

$$b = \frac{a \sin \mathrm{B}}{\sin a}, \text{ or } b = \frac{a \sin \mathrm{B}}{\sin (\gamma + \mathrm{B})};$$

$$\text{therefore } x = \frac{a \sin \mathrm{B} \sin \gamma}{\sin (\gamma + \mathrm{B})}$$

$$\text{therefore } y = \frac{a \sin \mathrm{B} \cos \gamma}{(\sin \gamma + \mathrm{B})}$$

that is, log. x = log. a + log. sin B + log. sin γ + compl. log. sin (γ + B) log. y = log. a + log. sin B + log. cos. γ + compl. log. sin (γ + B) into the following scheme for calculation:

ılated in this way 6,500 points by means of the abscissas and
. I am deeply indebted to Mr. C. J. Pauli, assistant engineer,
ealous manner in which he aided and assisted me during this
l for the prompt and faithful manner in which he has always
ed the numerous and varied duties which have fallen to his lot.
onth and twenty-five days, we together succeeded in finishing
dious and tiresome work. After carefully and minutely pre-
is work came the mapping and plotting of the same.
mean time all the soundings taken were reduced to low water
nd the observations of the theodolites, also compass bearings
ths of base lines, were inserted on the sheets. The low water
as taken as the standard, and the height of water on each chain
o this standard without trouble.
now easy to plot these soundings on paper, and as it was con-
est for the sounding sheets of the different chains to read in
t, a scale of 12 inches to 1,000 feet, or 63.36 inches to a mile,
pted. First, the station of the steamer, as observed by the
es, was laid down by abscissa and ordinate; then, at this point,
ng was plotted as indicated by compass for the line of skiffs,
is line were then plotted the intervals as they existed between
nder at each of these points. The depth of water was inserted
ted by sounding book; after all these sounded points were plot-
line was drawn, which line connected all soundings indicating
four feet of water. In this manner horizontal curves were pro-
hich gave to the eye an exact view of the bottom of the river.
h of the improvement was set at four feet below low water of
stimates and plans for enlarging the channel to 200 feet were
e easily and accurately obtained.
r great advantage which here exists is, that each and every
the map in reference to the base line, can be accurately dis-
gain by simply putting the instruments on the base line and
the skiff until the two bearings of the instruments strike the
he same, as in the sketch, (see Fig. 8.) Suppose it necessary to
he rock marked A, B, C, these points could be laid out accu-
aforesaid. It is only necessary to calculate the angles in the

lines were shaded in blue, and give a perfect picture of the bottom of the river at the depth of four feet below the low-water mark of 1864, (see Fig. 9.) As all the intended improvements were laid down on these last-named maps, they were called "working maps;" and those maps on which the figures were only written down from the sounding books were called "sounding maps." In this manner there were plotted, between the 1st of February and the 15th of May, 1868, the following list of maps:

For Lower chain, one sounding map and one working map, 4×3 each.

For Moline chain, one sounding map and one working map, 4×4 each.

For Duck Creek chain, one sounding map and one working map, 5×4 each.

For Campbell's chain, one sounding map and one working map, 5×4 each.

For Sycamore chain, one sounding map and one working map, 4×4 each.

For Smith's chain, one sounding map and one working map, 4×3 each.

For different patches, two sounding maps and one working map, 3×1½ each.

In addition to this work two profiles were made, one pertaining to the Iowa shore and one to the Illinois shore, on which, at every station, the levels for high and low water are given. The horizontal scale in these profiles are 7,200′=12 inches, and the vertical scale 48′=12 inches. The entire survey extending from Davenport to Le Claire is to be plotted as a general map, on a scale of two inches to 1,000 feet, or 10.56 inches to a mile. The observations of water gauges were also plotted, and by the curves thus obtained, the difference between the highest and lowest water, or rather the extreme range of the same, during the year from May 1867 to May 1868, was shown, as seen by the following table:

At West Davenport	11.1
At the bridge at Davenport, Lower chain	12.1
At Gilberttown or Moline chain	10.0
At Duck Creek chain	9.6
At Valley City or Campbell's chain	9.2
At Station 53, or Sycamore chain	8.7
At Station 55, or Smith's chain	8.9
At Le Claire	8.4

The highest stage of the water in the year 1867, at the gauge attached to the railroad bridge at Davenport, and reading zero point equal to low water of 1864, was, June 27, + 14.4, and the lowest stage of water in the same year was, December 1, + 2.3. In the spring of 1868, at Duck Creek chain, one day's additional soundings were taken for the purpose of connecting the excavated part of the work in the copper dam and deep water, and recently the current and velocity were accurately observed at Sycamore and Campbell's chains. To accomplish this the base lines used for sounding were occupied by two theodolites, and a float submerged to the surface of the water sent floating down stream; and accurate observations of the same taken every minute, to prevent mistakes as to time. A timekeeper was stationed between the standpoints of theodolites, who at 15 seconds before the expiration of a full minute caused a signal of *attention* to be given; at this signal the observer clamped his instrument, and with the tangent screw followed closely the small flagstaff in the float, until at the full minute, when another signal was given by the timekeeper and the bearings were simultaneously taken at each instrument. At Sycamore 16-inch lines were taken at intervals of from

100 to 150 feet, and 11 of the same were taken at Campbell's chain. The velocity, that is to say, the surface velocity, at Sycamore chain varies somewhat on the chain itself. The greatest velocity is 380 feet per minute, or 6.20 per second; and the smallest 220 feet per minute, or 3.40 per second.

In that portion of the river between the chain and the Iowa shore the greatest velocity is 300 feet per minute, or 5 feet per second, and the smallest is 180 feet per minute, or 3 feet per second.

At Campbell's chain, the greatest velocity is 200 feet per minute, or 3.33 per second, and the smallest velocity is 90 feet per minute, or 1.5 per second.

Between Campbell's chain and the Iowa shore, the greatest velocity is 180 feet per minute, or 3.0 per second, and the smallest is 70 feet per minute, or 11 per second.

The current and velocity on the other chains will be observed during the coming month. I would in conclusion add the following items: The river survey extends from Davenport to the town of Le Claire, a distance of 14 miles; 28 miles of level were run between the above-named places. The surface of the different chains which were sounded this year contains 16,300,000 or nearly 0.6 square miles.

Respectfully submitted.

E. F. HOFFMANN,
Lieutenant 35th Infantry United States Army.

Brevet Major CHAS. J. ALLEN,
Captain Corps Engineers.

[Sketches accompanying report of E. F. Hoffmann, lieutenant 35th United States infantry, pertaining to the improvement of the Rock Island rapids, Fig. 1 to Fig 11.]

H 9.

Abstract of contracts made on account of the improvement of the Rock Island rapids of the Mississippi river.

No.	Name of contractor.	Residence.	Date of contract.	Nature of contract.	Price per cubic yard.
1	Chas. G. Case & Co..	Fulton, N. Y.	June 28, 1867.	For removing the rock—	
				At Smith's chain	$14 00
				At Sycamore chain	13 00
				At Crab island	13 00
				At St. Louis chain	13 00
				At Campbell's chain	15 00
				From Campbell's chain to Duck Creek chain	13 00
				At Duck Creek chain	10 00
				At Moline chain	10 00
				At Lower chain	10 00

J. H. WILSON,
Lieut. Col. 35th Infantry, Bv't Maj. Gen. U. S. A.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, August 18, 1868.

H 10.

Abstract of proposals received at the United States engineer's office at Davenport, Iowa, June 10, 1868, for the improvement of the Rock Island rapids of the Mississippi river.

No. of proposal.	Names of bidders.	Residence.	Conditions.	Price per yard.	Remarks.
1	Reynolds, Saulpaugh & Co.	Rock Island, Ill..	Agreeable to the terms of advertisement.	$12 50	
2	Charles G. Case ..... F. D. Van Wagenen.. Elliot Harroun	Fulton, Oswego county. N. Y.	Agreeable to the terms of advertisement.	11 50	

I certify that the above abstract is correct.

J. H. WILSON,
Lieut. Col. 35th Infantry, Bvt. Maj., Gen. U. S. A.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, August 18, 1868.

H. 11.

DUCK CREEK CHAIN, R. I. RAPIDS,
July 15, 1868.

DEAR SIR: Your favor of the 14th received last evening. I shall be glad to give any information in my power which you may ask concerning "power of engines," chiseling operations, &c.; but your request for reply by return mail gives me a short time to prepare a report of the kind in engines of chisel boats (single) each 12 horse-power; about two-thirds of their capacity does the work.

Engines of dredge (double) each 12 horse-power; two-thirds of their capacity used in rock excavation and four-fifths in puddling for coffer-dams. Engine used for pumping coffer-dam at Duck Creek chain, 8 horse-power and not enough, when worked to its utmost capacity. Engines of steamer Le Claire, when worked at the greatest pressure allowed by license, 20 horse-power each. Engines of steamer Pearl at a moderate pressure 30 horse-power each.

The first attempt (that I ever heard of) at cutting or breaking rock under water by means of chisels was made in the summer of 1855, at "Brown's Patch" on the lower rapids, by Major I. G. Floyd, United States agent, and he did claim to be the originator of the idea. The chisel used consisted of a stick of oak timber twelve feet long, about one foot square, with bars of railroad iron let into the sides to increase the weight and form "ribands" to work in the uprights of the boat to keep the chisel rigid in a vertical position. This timber was shod with a conical socket of wrought iron weighing about 300 pounds, having a pyramidal point of steel. The manner of operating was similar to an ordinary pile-

o do anything that winter. These chisels were of wrought iron
feet long, ten inches in diameter, with a pyramidal steel point,
t 3,300 pounds. The upper end worked loosely in a "head" from
the chisel was suspended. This was to allow the chisel to glance
ut injuring the boat. This "head" was made of a combination
te iron, steel and rubber springs—"Osgood's patent"—and that
only part of the machinery that I ever heard of being patented,
h I hear that Mr. Osgood claims a patent on the chisels used here,
othing of his manufacture here has "patent" marked on it.
he fall of 1858 these boats were brought out in charge of Andrew
, esq., who may be said to have made the idea of chiseling suc-
l. Two months of breaking down and repairing brought about
rous alterations. The chisels were not proportionally constructed,
he concussion on the rock caused them to crystallize and break.
'patent heads" found to be too heavy, as their own weight in
would cause them to fly in pieces. Chisels were lengthened to
t and weight increased to 4,400 pounds; "heads" made of blocks
t wood bolted together; the points of the chisels were also altered
edge shape. After this their work began to show, and more rock
aken out in the month of December than had ever been taken out
hole season by other methods. 1859, boats worked from 20th of
till 23d December, except one month during June freshet. Did
work at Lower chain. 1860, worked from 6th of April till last of
er, then stopped; the appropriation of $200,000 being exhausted.
1861, were sold to contractors on canal around the falls of the
worked during low water season of 1861 and 1862. The upper
e of rock (20 inches) was removed, but the next course being nine
ick it was found impossible to break, and their use was abandoned.
f them was sold to the Kanawha River Improvement Company, but
used, as the work was suspended. Have worked in sandstone,
esian and gray limestone, flint, conglomerate and granite boulders.
d free stratified rock of any kind can be worked to advantage.
(at Duck creek) is the most difficult of any that I have ever seen
d and pay expenses. Giving chisels that are properly constructed
d stratified rock not over three feet in thickness, there is no diffi-

make it as complete as I should have liked. All that I have said concerning chisels I am an eye-witness to, having seen the whole of it. Have never heard of chisels being employed at any other places, except to remove a large rock at the steamboat landing at Albany, New York.

* * * * * *

Very respectfully, your obedient servant,

H. S. BROWN.

Major CHARLES J. ALLEN,
U. S. Engineers, Davenport, Iowa.

H 12.

DUCK CREEK, IOWA, *July* 16, 1868.

SIR: In accordance with your instructions of the 23d ultimo, the following report of the operations upon Rock Island rapids, during the portion of the past year that I have been connected with the work, is respectfully submitted.

My connection with this work commenced in the early part of October last. At that time, the contractors, Messrs. C. G. Case & Co., were making preparations for the removal of the obstructions at Duck Creek chan A coffer-dam, about 400 feet long and 200 feet wide, had been constructed, embracing the heaviest part of the cutting. Irregular patches requiring more or less cutting, extended for some 800 feet above, and 1,400 to 1,800 feet below the dam. These it was proposed to reduce by means of chisel boats, two of which had just been put in operation on the work above the dam. These chisel-boats consist of flat-bottomed barges, provided with a steam-engine and machinery similar to that of a pile-driver, for raising and dropping a steel-pointed wrought-iron shaft called a chisel. The boat is about 60 feet long. The chisel, with its guides and accessory framework, is placed at one end of the boat. The other is provided with a "speed," similar to those of a dredge. Near the chisel is a windlass, connected by ropes with anchors to the right and left, for swinging this end of the boat; the other end being kept stationary by means of the "speed." The manner of operating the boats as follows: The depth of the proposed cutting below the surface of the water—which depth varies from day to day—is ascertained, and a mark made on the chisel-guide, with which the head of the chisel coincides when the cut is deep enough. The boat is swung, by means of the windlass, till some point of the bottom is reached requiring cutting, when a succession of blows is struck till the chisel reaches the required depth. While the chisel is being raised for the next blow, the boat is swung a proper distance and the cutting proceeds; the face or heading being always an arc of a circle of about 60 feet radius. The boats are usually placed with the chisel down stream, and swing through an arc of about 90 degrees. When one furrow is completed, the boat is moved a suitable distance up stream by means of a kedge-anchor, covering in its progress a strip of ground about 60 feet wide. After the chisels have completed their work, the rock is removed by dredge.

Considerable difficulty and delay arose at first, from the fact that the chisels had been made too heavy for the machinery provided for working them. It was necessary to have their weight reduced from about

nds to about 5,800 pounds, by turning off the outside in a lathe.
ual hardness of the rock at this point was also a source of con-
delay, it being necessary to send the chisels to Chicago to
n sharpened.
ogress, on the whole, was such as to demonstrate the practica-
his method for shallow cuttings. About 622 cubic yards of rock
oved by the chisels and dredge during the fall.
ompanying sketch represents the coffer-dam made use of by
o. [For diagram see original.]
a, are wall pieces, 6 by 8 inch timber, about 16 feet long. The
carfed as shown at *e*, and united to each other, and to the cor-
g timbers on the opposite side of the dam, by tie-rods *b*, *b*, of
one-half by one and one-half inch. A similar rod also passes
he middle of each pair of timbers. The ends of these rods are
y pins and collars. Flat iron is used instead of round, for the
it the holes for securing the ends are made with greater facility,
being placed with the flat side vertical, there is less danger of
ous cavity being formed underneath the rod, by reason of the
packing of the filling, in which the water might find its way
he dam. *c*, *c*, planking of dam, two inches thick; *d*, *d*, sink-
, employed in sinking the lower wall pieces to their places.
de of constructing the dam is as follows: Timber cribs are
loaded with stone, some 30 feet apart in the clear, in a line
to the current, and somewhat above the head of the proposed
nding several yards past it on either side. Strong timbers are
one crib to another on the up-stream sides, which stand to an
bout 45 degrees. A covering of planks is laid along the whole
the crib-work, with one end resting upon the timbers and the
n the bottom, forming a continuous obstruction to the flow of
, and a large extent of comparatively still water on the down-
le. Timber work for the corner of the dam is framed and sunk
per place, with two pairs of lower wall timbers attached by
tie-rods to the frame work, secured to each other by the middle
he outer ends floating freely. Rafts are moved on each side of
f the coffer-dam, leaving sufficient space between them for
An additional pair of lower wall timbers is then attached to
ng ends of those already in, and secured to one another as
A pair of upper timbers, which come above the surface of the
then attached to the fixed part of the dam. The sinking
d, are spiked to the pair of lower timbers next the fixed part
a, at right angles to the length, and projecting some 15 inches
m. This pair of timbers is now sunk till the ends of the sink-
rest on the bottom. The upper timbers are raised a few inches
surface of the water and spiked to the sinking plank. These
weighted, so as to keep the timbers in place. The side planks,
are sharpened at the lower extremity, are then driven into
act with the bottom, and spiked to the upper wall timbers.
is then ready for the filling.
rk of excavating the rock in the space inclosed by the coffer-
commenced about the 20th of October, and completed about
e of December, 1867; the total quantity removed being 5,184
ls. Blasting with gunpowder was the only means employed
ing the rock.
rable loss was experienced by the contractors at the breaking
ce in the spring. They had left their boats in the fall, moored

to the lower end of the coffer-dam, which they expected would offer an effectual barrier to the ice. At the breaking up of the ice, however, the water rose so as to entirely submerge the coffer-dam, sweeping away all their boats except the dredge, which was removed to a safe position. Most of the boats were recovered, but all in a more or less damaged condition. As soon as the water became low enough, the chisel boats and dredge resumed work at Duck creek chain, removing, up to the 30th of June, 1,092 cubic yards, making 6,898 cubic yards thus far removed from this chain.

The contractors commenced work upon the Moline chain as soon as it became apparent that there was no great reason to apprehend a June freshet, and had on the 30th ultimo finished their breakwater and made a beginning upon the coffer-dam.

Very respectfully, your obedient servant,

JOSEPH P. FRIZELL,
Civil Engineer Assistant.

Brevet Major CHAS. J. ALLEN,
Captain Corps of Engineers, Davenport, Iowa.

Report upon the survey of the Illinois river.

UNITED STATES ENGINEER OFFICE,
Davenport, Iowa, December 17, 1867.

GENERAL: Having been designated by direction of the Secretary of War, through engineer orders dated Washington, May 8, 1867, as a board "to conduct surveys and examinations, and to prepare plans and estimates for a system of navigation by way of the Illinois river, between the Mississippi and Lake Michigan, adapted to military, naval, and commercial purposes, in accordance with the act of March 2, 1867," we have the honor to submit the following report:

In carrying out the instructions of the engineer department, we have steadily kept in view the following considerations:

1. The selection of the best route for the purposes proposed.

2. The capacity which should be given to the improvement so as to adapt it most fully to the requirements indicated in the orders of the War Department.

3. The accomplishment of the object with the least possible cost consistent with the magnitude and permanency of the improvement, and in such order as to secure the greatest advantage to the commerce and navigation of the country.

A detailed report of the results of the resurvey of the Illinois river during the latter part of 1866, under the direction of Brevet Major General J. H. Wilson, was made on the 17th of February, 1867, but as his operations were confined to that part of the river below La Salle, it was thought necessary to continue the surveys to Lake Michigan by all the possible routes, before absolutely fixing the details of the plan of improvement. Accordingly, at as early a date as the season would permit, we organized, under the general authority heretofore cited, three surveying parties under the immediate supervision of Civil Engineer Assistant James Worrall, for the purpose of making a thorough and exhaustive examination of the entire region lying between the southern

1 of the lower Illinois. To the third party, which was organized ıugust, under the control of Civil Engineer Assistants L. L. Nich- R. E. McMath, was assigned the duty of making a careful hydro- surrey of the bed of the Illinois river from La Salle to Grafton Mississippi, paying particular attention to the location, cause, r, and extent of the different sand bars and obstructions to ɔn during low water, also to gauging the river and its different es, and making examinations of the various points likely to be ıs sites for locks and dams. Each of these parties finished its ıs by the first of December, having been favored by fine weather ıtremely dry season. For the details of their work the depart- especfully referred to the report of Civil Engineer Assistant herewith submitted.

the summer we made a personal examination of the country ɔnded in the survey, and have fully investigated all points of onnected with the proposed system of navigation, and by the ıe extensive and careful surveys made under our direction, with the survey of last year made under the direction of Gen- on, that of Mr. J. B. Preston made in 1857, and fortunately for tigations, the large mass of facts bearing upon the questions which had been accumulated during the last 30 years by Mr. ɔding, chief engineer of the Illinois and Michigan canal, we t that all the necessary information has been obtained upon base a definite plan of improvement, to make a final and eco- ocation of the general line of works, and to estimate their cost gree of accuracy not hitherto attainable.

ıreful examination of the report and profiles of this year's sur- the map herewith submitted, it will be seen that the location esent canal from Bridgeport to the valley of the Des Plaines e advantageously or economically changed; that it is the best, and most direct route which can be found, there having been n enough work already done in this line to counterbalance the ut not superior advantages of the slightly lower but more tor- ıte by the way of Mud lake; that the Calumet river and Saga- ek route, along what is known as the Calumet feeder, would eat deal more than either of the others, being longer and end-

of the country require, the government must follow the general line of the Illinois and Michigan canal and the Illinois river. When it is considered that the summit of the Fox and Wisconsin river line is 315 feet, and that of the Lake Winnebago and Rock river is 285 feet above the level of Lake Michigan, it will be seen that the line recommended by us is the only feasible route for deep-water communication between the great lakes and the Mississippi river, equally adapted to military, naval, pure commercial purposes.

PLAN OF IMPROVEMENT.

We have therefore to respectfully recommend that the improvement in question shall be made by widening and deepening the present canal from Bridgeport to the head of Lake Joliet, with the exception of a section of 11¼ miles between Summit and "the Sag," where it will be cheaper to excavate an independent canal. From Lake Joliet to Marseilles the line should follow the bed of the river, the necessary depth being secured by a system of locks and dams. At Marseilles it will be necessary to construct a piece of independent canal in order to pass the Grand Rapids of the Illinois—striking the river again at or above Ottawa, as may be found most economical. From the latter point to the mouth of the river, the necessary navigation should be secured by a system of dams and locks. It is also recommended that all the canal on this line shall have a *width* of not less than 160 feet, and a navigable depth of six feet, corresponding to the lowest known level of the water in Lake Michigan, an average depth of between seven and eight feet; that the present summit shall be cut down so as to secure this depth in the canal from the inexhaustible reservoir of Lake Michigan. The locks in this improvement, in order to admit of their fullest use by naval and commercial vessels, should be 356 feet long between the gates, 75 feet wide in the chamber, and give a minimum draught of seven feet. The slack water of the Illinois should be made so as to secure a navigable depth of seven feet at the lowest known stages of water. The whole to be constructed in a durable and substantial manner, without display or ornament, but with the single object in view of securing the greatest amount of utility at the least practicable cost.

GENERAL CONSIDERATION OF THE PROPOSED IMPROVEMENT.

No fact can be better established than that the system of navigation between the Mississippi and Lake Michigan, by way of the Illinois river, should be adapted to the steamboats and barges employed in the navigation of the Mississippi and its principal tributaries, and not to ocean and lake vessels, except such as are required for the defence of our lake commerce and cities. In other words, the produce of the west, on its way to eastern markets, must be transferred to a different class of vessels as soon as it reaches the lakes; and hence, in determining the dimensions of the canal, it will be amply sufficient for all practicable purposes to arrange it for the navigation of the largest class of river steamboats. "It will be remembered that the western steamboats are built with overhanging guards, so that a boat 75 feet wide over all will not usually exceed 45 feet in the hull. Assuming this as a maximum width of hull, with a depth of six and a half feet, the theoretical width of the water surface in which the boat could move as in an indefinite

and occupy the river, rather than enlarge the canal to the requi-
imensions.

s canal, from a point eight miles southwest of Chicago, follows the
of the Des Plaines, a tributary of the Illinois, until it forms a
on with the Kankakee river, some 50 miles southwest of Chicago,
which the river is known upon the map as the Illinois. The lat-
me would have been most appropriate for the Kankakee above
oint, as it is the main river, and Des Plaines, in low water, con-
s a comparatively insignificant quantity to its volume.

Kankakee supplies water sufficient to make a good slack-water
tion; the Des Plaines of itself does not, and although the direc-
the former was such that it was not probable that a favorable
tion with Lake Michigan could be made through its channel, yet
deemed advisable to determine that fact beyond cavil. We,
re, caused a survey of the river to be made from its mouth to
e east line of the State of Illinois, where it has but little current
ins by numerous crooked channels a large extent of country
he Kankakee marshes, but embracing much valuable land, por-
which are well timbered. These surveys and examinations, as the
anying report will show, have been highly satisfactory, and fur-
nuch useful information. The question of a connection through
nnel with Lake Michigan, for an improvement of large capacity,
n definitely settled:

ere is too great an elevation (100 feet where the line was run)
the Kankakee and the Calumet rivers, through which the con-
could be most cheaply made, if made at all.

e Kankakee river, which at the State line is 40 feet above Lake
n, would not afford sufficient water to supply a canal and lock-
n ways for a maximum business.

e distance would be 50 miles greater than by the Illinois and
n canal, if the connection were made with the lake at the mouth
Calumet, which is the best point south of Chicago.

s believed to be impossible to construct a good and safe harbor
outh of the Calumet, available at all times, and no other should
ted as the terminus of the proposed improvement.

ter route by way of Fox river, which forms a junction with the

the canal and railroads to this portion of the river, and the numerous dams and large amount of lockage necessary to improve it, render it entirely improbable that tolls enough could be collected to pay the cost of superintendence and repairs, to say nothing of the cost of construction.

For particulars in regard to the character of the river and expense of its improvement, reference may be had to the accompanying report of Colonel Worrall.

For a canal and river improvement of a capacity sufficient to pass such gunboats as required, and river steamers of 800 and 1,000 tons burden, from the Mississippi to Lake Michigan, no other route, in our judgment, can be compared with that by the Illinois river, and the Illinois and Michigan canal. It follows the course of what was unquestionably once the great outlet of the lakes towards the Gulf of Mexico, and through which only is it now practicable to again turn their waters in that direction. On all other routes proposed there is a considerable ascent from the lake to the summit, involving the necessity of an additional amount of lockage and of providing a supply of water from sources much less reliable than that inexhaustible reservoir, Lake Michigan.

The Des Plaines river rises in the State of Wisconsin and runs nearly due south, parallel with the lake shore, and generally not more than eight or ten miles from it, until it reaches a point about 13 miles in a southwest direction from the mouth of Chicago river. Here is a slight depression, a mile or more in width, extending across from the Des Plaines to the south branch of Chicago river, through which a part of the waters of the former river, in time of floods, flow into the lake. In this depression is what was once known as Portage lake, (so designated on the old maps of the country,) but now better known as Mud lake, a succession of shallow ponds on the same level connected with each other and with the Des Plaines river, and extending about six miles towards Chicago river. This was the portage or carrying place between the waters of the lakes and the Mississippi made memorable by the early French *voyageurs*, and so well known to fur traders. But Portage or Mud lake has ceased to exist, the shallow ponds having been drained, and the impassable swamps rendered valuable land.

There can be no doubt that through this depression there was once an outlet from the lakes to the Mississippi, which was closed by the recession of the waters of the lakes. Even now at the present stage of Lake Michigan its surface is only between *eight* and *nine* feet below this summit. The Des Plaines river, from the depression described, changes its course and runs in nearly a southwest direction until it forms a junction with the Kankakee. The river itself, except in floods, is very shallow, being often reduced in dry seasons to a mere brook, discharging less than 1,000 cubic feet of water per minute. But the valley averages a mile wide, and is terminated on both sides by well-marked terraces which become higher and higher as they approach the Illinois. Evidence at every step presents itself that the water, when this was the great outlet of the lakes, extended from bluff to bluff.

The Illinois and Michigan canal, from the commencement of the through cut, at a point on the south branch five and a half miles above the mouth of Chicago river, is constructed for the distance of eight miles on a tangent line to summit, where it reaches the valley of the Des Plaines, down which it flows to the mouth of this stream, and thence down the valley of the Illinois (which in this part of its course averages about one and a half mile wide) to La Salle, its western terminus.

We are fully satisfied, from a thorough examination and survey of the canal and the country contiguous, that for the most of the distance from Chicago river to the vicinity of Joliet, it will be expedient to follow the present line of canal, enlarging and deepening it (when deepening is required) to the requisite capacity. By far the most expensive part of the whole contemplated improvement will be between Chicago and Lockport, where the first lock was located on the plan of the canal adopted by the canal commissioners of the State of Illinois in 1836. A part of the work was executed upon this "deep cut plan," which was to cut down the summit level and draw the supply of water directly from Lake Michigan.

The canal upon that plan would have been throughout not less than 60 feet wide at surface, 36 feet on the bottom in earth, and 48 feet in rock excavation, and six feet deep at the lowest stage of Lake Michigan, (the extreme periodical fluctuations of which are about four feet.) The capacity of the canal was not diminished by the change of plan in 1845 from the deep to the shallow cut. The only change was upon the summit division where the level was raised from eight to ten feet above the bottom of the proposed deep cut, and water supplied from the Des Plaines river, the Calumet feeder, and by the pumping works at Bridgeport.

The length of the canal from its commencement at Chicago to its terminus at La Salle is precisely the same as upon the original plan, 96½ miles.

The excavations which have been made in constructing the present canal on the raised level, and those which were formerly made whilst the work was in progress on the "deep cut" plan, have determined with considerable certainty the character of the most of the material to be excavated. The first eight miles, except two or three feet upon the surface, consists almost entirely of indurated clay, exceedingly hard, but which is now being successfully excavated by steam dredges; a few veins of quicksand, of no great thickness or extent, have been found on this part of the line, and it is not believed that they will cause any serious embarrassment in the construction of the enlarged canal. The excavation of this part of the canal from the original surface will vary from 13 to 19 feet.

At eight miles from Chicago the canal enters the valley of the Des Plaines river, and the character of the excavation becomes much more difficult. For the next 11¼ miles a large part of the material to be excavated consists of cemented clay and gravel, or hard clay, in which a large quantity of boulders are embedded. Much of this work, and probably the most of it, can be excavated with powerful steam dredges, but the operation will necessarily be slow and expensive.

There are in places considerable quantities of rock (stratified limestone) that will vary in depth above bottom from two or three to eight or ten feet. This, however, will be a comparatively small part of the whole excavation. The depth from the original surface will generally vary from 17 to 19 feet. We are of the opinion that it will be found expedient in constructing a canal of so large capacity as the one proposed, in a material of such exceedingly difficult character, to make it entirely outside of the present line, so that the whole work may be prosecuted in the most advantageous manner at all seasons of the year without interfering with the navigation of the canal.

Should the line be changed as we suggest, it should be located parallel with the present canal, and for the most of the distance so near to it as to leave only room for the deposit of the material excavated. The

facilities for construction would be much greater on the new than the present line, and although the quantity of excavation would be considerably increased, the aggregate cost probably would not. On the present line the construction of the walls to protect the banks, and the excavations of stratified rock and such other material as cannot be excavated by steam dredges, must be prosecuted wholly during the suspension of canal navigation, but on the new line the work could progress steadily to completion.

At the distance of about 18½ miles from the commencement of the canal at Chicago river, a bed of stratified limestone extending entirely across the valley (though not rising above the general surface) presents itself and continues to the running out of the lake level near Lockport. This rock, where it has not been disturbed by the excavation of the present canal, is covered with a slight alluvial deposit, generally one or two feet in depth, but in some places even less. From the commencement of this rock excavation, a mile below the mouth of the Calumet feeder to Summit lock No. 2, below which the canal was completed on the "deep cut" plan, the levels on the natural surface of the rock range from 11 to 18 feet. This distance is 7⅛ miles, and only 235,000 cubic yards of rock remain to be excavated to complete the canal on the original plan, nearly 1,000,000 yards having been already excavated.

Our estimate for the summit division (from Chicago to the running out of the lake level at Lockport) are intended to make the bottom of our supposed enlarged canal conform to that of the present canal where it is excavated to the depth required upon the original "deep cut" plan. That plan was intended to give a depth of six feet at the commencement of the through cut below the *very* lowest stage of Lake Michigan, and this stage has occurred but once in the last 31 years, and then only for a very brief period. At an average low stage of the lake there would be a depth of not less than 7 feet, and at present, a medium stage, 8 feet. The highest stage which has occurred in the last 31 years would have given a depth of 10 feet. It was intended to give a declivity on the bottom of the canal, upon the original plan, of ten-hundredths of a foot per mile, or two and nine-tenths feet for the whole summit division. Our levels show some five inches less, but we deem the declivity quite sufficient, and in our estimates have included the cost of making the lock and the embankments at the lower end of the summit level high enough to diminish the current, if necessary, by diminishing the declivity at surface, and increasing the depth, of course, on the lower portion of the level.

From Chicago to Lockport, where the first lock below the lake level is located, we have already stated that for the most of the distance the larger canal proposed should embrace the present canal. Where the line is changed it will be mainly with a view to increase facilities in construction, and not because any particular advantage can be obtained in the nature of the ground. The difficulties of construction would originally have been substantially the same on each.

For half the distance between Lockport and Joliet, no advantages can be gained by any deviation from the present line, but some expense may be saved by a different adjustment of lockage on the enlarged canal.

Below this point three different lines were surveyed to the head of Lake Joliet, an expansion of the Des Plaines river, two miles below the city of Joliet.

The *first* of these lines follows the present canal through Joliet, and the pools formed by the two dams across the Des Plaines now in use

would be occupied by the proposed improvement. These dams are built of stone upon a rock foundation, and, having stood more than 20 years without injury, may be regarded as sufficiently permanent. It will require considerable rock excavation under water to form a channel of sufficient width for the proposed improvement, and there will be considerable difficulty in obtaining the necessary room at and near the two dams without injury to the improved property, or that which is regarded as very valuable. A short distance below the lower dam the line for the proposed improvement would leave the present canal and be made as direct to the head of Lake Joliet as practicable.

The *second* line leaves the present canal near the State penitentiary and passes through the eastern point of the city in a depression known as the slough, crossing Hickory creek 20 chains above its mouth, thence following near the foot of the bluff on the east side of the valley to the head of the lake.

The *third* line follows the foot of the bluff on the east side of the valley, keeping entirely out of the limits of the city to the head of the lake.

The relative advantages and disadvantages of these three respective lines are fully set forth in Colonel Worrall's accompanying report, and whichever be adopted, the work can be so constructed as to render it permanent and free from any dangerous contingencies. From the head of Lake Joliet to La Salle no part of the present canal can be made available if the Des Plaines and Illinois rivers be occupied by any portion of the improvement. Having once locked down to the level of the river the canal will be at a greater elevation than the proposed improvement, and cannot therefore form a part of it, or diminish its cost.

The question of enlarging the canal to the requisite capacity (say 160 feet wide) throughout its entire length, has been thoroughly investigated by us, and all the arguments in favor of such enlargement, as compared with a river improvement running parallel with it, duly considered.

1. The present canal, for a canal of its capacity, is well located, but at two or three points, as at the Kankakee bluffs near the junction of the Kankakee and Des Plaines rivers, and at the Rockwell bluff, a short distance above La Salle, the canal could not be enlarged to 160 feet in width, except at great cost, nor without rendering the work very insecure when completed.

2. The construction of numerous bridges, culverts, waste weirs, ditches, &c., and three or four expensive aqueducts, and the expense of repairs and renewals for all time to come, would be a most serious objection.

3. The construction of vertical or slope walls through all earth work for the protection of the banks, and lining a portion of the canal where the excavation will be in coarse gravel, would be expensive and require more or less annual repairs.

4. The navigation of a canal 160 feet wide and 7 feet deep with large steamboats would be vastly inferior to that of a river from three to five times as wide and generally of greater depth.

5. On the other hand, the enlarged canal would not be subjected to any considerable danger from gorges of ice, which are sometimes formidable in the Illinois river, and which must be strongly guarded against in the construction of the locks and dams for the river improvement.

6. The enlargement of the canal would more directly benefit certain fixed interests, as warehouses, &c., built with reference to the business of the present canal, than the river improvement.

After comparing carefully the advantages and disadvantages of the two modes of improvement, we have no hesitation in recommending the river route from the head of Lake Joliet to the mouth of the river, with only such short reaches of canal at the different locks as may be found necessary.

From Marseilles to Ottawa, where the fall in the Illinois river is very rapid, including what was formerly known as the "Grand Rapids of the Illinois," it will doubtless be best to construct an independent canal on lower levels than the present canal, and this canal may be brought back into the river at a point two miles below Marseilles or at the mouth of Fox river, depending in some degree upon the local manufacturing interests, which should be accommodated so far as can be done without materially adding to the cost of the work or marring its efficiency for purposes of navigation.

SLACK WATER.—ARGUMENTS IN FAVOR OF RIVER IMPROVEMENTS.

In adopting the river improvement below Lake Joliet instead of enlarging the canal, we have been governed by the following reasons:

1. It is the cheapest improvement in its original construction and can be made in the shortest time, and without interfering in any respect with the use of the present canal during the construction.

2. The pools of the dams being broader and deeper than the canal, the navigation will be easier, and steamers with many barges in tow can pass each other much more rapidly.

3. If it be desired hereafter to make the improvement of greater capacity, it can be done at a very small cost, by simply raising the height of the dams.

4. As all the water drawn from Lake Michigan and received into the Des Plaines and Illinois rivers from tributary streams will contribute to their channels for navigation, none of it being lost by filtration, the full depth requisite can be more certainly maintained than in a canal.

5. The works necessary to make the improvement, consisting mainly of locks and dams, if constructed in a permanent manner in suitable locations, (as they should be if constructed at all,) the expense of superintendence and annual repairs will be less than required for an independent canal, and to those acquainted with the expenses and difficulties of maintaining canals, this will be recognized as a consideration of great importance.

It has been asserted that it is unnecessary to provide for a navigable depth of seven feet in the Illinois river when the Mississippi river itself below the mouth of the Illinois has at times a less depth than this. We have fully considered this objection, urged mainly against the improvement by locks and dams, and for the following reasons think it should be disregarded:

1. There is usually but a short period during the season of navigation when there is not a depth of water of six or seven feet in the Mississippi below the mouth of the Illinois, and frequently the Mississippi being high from melting snows about its source, or that of the Missouri, affords good navigation for the largest boats when the Illinois is scarcely navigable at all.

2. We entertain no doubt that the depth of water in the Mississippi from the mouth of the Illinois to that of the Ohio can be materially increased during the dry season by a judicious system of improvement.

The interests of commerce and navigation now require and must necessarily compel the commencement of such an improvement before lapse of many years.

3. It is manifestly necessary to secure a depth of at least seven feet, which shall be *always available*, if this artificial navigation should ever be required for "military and naval purposes," and we deem it sound policy to secure this depth of water for commercial purposes if it can be done without a disproportionate increase of cost. It is a well-known fact that vessels of every class are propelled at much greater speed and economy in deep than is possible in shallow water.

4. The depth of seven feet through three hundred and twenty-two miles of navigation, traversing one of the most productive countries in the world, can be secured beyond any contingency by the plan proposed, at a cost only slightly, if any, in excess of what it must cost to make an open channel navigation only four feet deep.

When it is considered that it is by no means certain that the latter is practicable at any cost, and that the former would be at least three times as valuable for all purposes, there remains but little room to doubt which plan should be adopted.

From the reports and profiles herewith it will be seen that this system of improvement will submerge but little if any valuable land. The height of the bottom lands above low water in the river, except such as are now low and marshy and inundated by a slight rise of water, is generally not less than from 10 to 15 feet, and in many places from 18 to 20 feet. The maximum height to which the water at the lowest stage will be raised by the highest dam will be only six or seven feet at the dam, and this will gradually diminish from the lower to the upper end of the pool, where it will be raised only two or three feet. All such lands, therefore, as would be overflowed by the construction of the dams would be overflowed now by a slight rise of the river, and cannot consequently be considered very valuable. From extensive observation and inquiry we are of the opinion that the influence of these dams upon the health of the country lying immediately along the river will be beneficial rather than injurious.

Amongst the many improvements to which our attention has been called in relation to the question of health, we refer confidently to the Monongahela and other slack-water improvements in Pennsylvania, the Muskingum, in Ohio, the Green and Barren rivers, in Kentucky, the artificial canal reservoirs in New York, Ohio and Indiana, and to the Rideau canal and Grand river slack-water improvements in Canada.

By referring to the report of civil engineer assistants Ulffers & McMath, it will be seen that most of the sand-bars in the Illinois river are due to local causes, and are undergoing but little change. Reasoning from cause to effect, we should not expect these sand-bars to be materially increased by the change which would be made in the bed of the river by the proposed improvement, but to the contrary, as the level of the water is raised by the dams, the tendency will be to cause all affluent streams carrying sediment to deposit it in the dead water within their own mouths, before they reach the main river. Where the affluents enter the river without flowing for any distance through the bottom lands, the sediment which they would otherwise bring into the pools may be almost entirely cut off by small dams a short distance above their mouths. Such dams should be built, no matter what plan of improvement may be ultimately adopted.

The dams for raising the river levels when constructed will be no

more likely to produce deposit in the pools above them than the bars and shoals at present in the deeper portions of the river above them, and experience has already demonstrated that no obstructions need be anticipated from this cause.

Extensive obstructions of slack-water improvements elsewhere have confirmed our previous convictions that there is no danger of any material damage or expense from deposit in the pools of the dams. We entertain no doubt that these dams can be so constructed as to be in little or no danger from ice or floods and of such materials as to last many years.

There are now dams of various heights, built upon various plans, which have been standing for the last 15 or 20 years (and some even longer) in Pennsylvania, Ohio, Indiana, Kentucky, and several other States, and in the Canadas, many of which have required but small repairs and bid fair to last for years to come. It is believed that the dams which it is proposed to build across the Illinois river can be made quite as secure as any of these, notwithstanding the defective nature of the foundations, as it is not proposed to raise the highest more than seven feet from low-water mark.

There is probably no river in the United States of a length equal to the Illinois from La Salle to its mouth (222 miles) which would have its width and current so little affected by a succession of dams which would deepen the water for the whole distance, as this river. The aggregate fall is only 28.62 feet, or an average of about 1½ inch per mile. The river is in fact a *natural canal*, but the depth of water is not *quite* sufficient for a good navigation without checking the current by placing barriers across it. These barriers or dams will not make *dead water* anywhere in the channel of the river, but merely diminish the velocity of the current, and that to such a moderate extent as to be hardly perceptible to the casual observer.

The water in the Illinois river at La Salle at the time of the highest flood which has ever occurred since the settlement of the country (February, 1832) was about 28 feet above low-water mark. In all the great floods since that period the water has covered the bottoms from bluff to bluff, making the river, say, from a mile to a mile and a half in width, which at such times has a strong current. It is obvious, then, that dams which would raise the water at the lowest stage but six or seven feet, would have no perceptible effect in time of floods. The width and velocity being both increased to such an extent in high water, the quantity of water in the river at a low stage would be but a small fraction of the whole volume in time of floods.

From our own observations of the effect of dams across other rivers, and the opinions of practical engineers and others who have closely observed these effects, we believe that a dam across the Illinois river raised six or seven feet above low water would have no sensible effect on the surface of the water when it was six or seven feet above the comb of the dam, and that steamboats fully laden could then pass over the dams without difficulty.

The volume of water in the Illinois river will at all times be sufficient to keep the dams so covered as, in a great measure, to prevent decay, and if constructed in a faithful manner upon the plan indicated, we believe that they will be very durable.

The character of the river bed and banks at the different points where the dams will be located will be similar, and consequently the only variation in the plans will be in the length and height. For further details

a lake is so broad that the current through it in ordinary stages
r is almost imperceptible. This will not be the case with the
nerally, even after the construction of the dams. The current
e but slightly retarded, and the thickness of the ice but little
d, and consequently it would be broken up, and the channel open
gation but little, if any, later than heretofore.

OTHER PLANS CONSIDERED.

bjections which have been urged against a slack-water improve-
the Illinois river from La Salle to its mouth by some persons
apprehend the effects which would result from such improvement,
luced many of the best engineers in the country to investigate
ct and devise different plans. Those which have been most gen-
lvocated are:
dredging and wing-dams.
drawing a sufficient supply of water from Lake Michigan to give
isite depth in the Illinois river.
vigation of the river may doubtless be much improved by the
hod, but it is doubtful whether any amount of expenditure upon
would give an available depth for navigation of more than four
treme low water in a channel 160 feet wide. Even the increase
pply which would be given by deepening the Illinois and Michi-
l on the summit division upon the plan now in progress, would
depth enough for canal boats passing through the canal in its
unimproved condition. Such an improvement, if it could be
manent, (of which we have great doubt,) would certainly fail to
"military, naval, and commercial purposes" designed to be
by the construction of the improvement, and we therefore sub-
timate of its cost. The estimate given by Mr. S. T. Abert, civil
in his report to General Wilson, dated February 15, 1867, is
not far from the truth. The amount is $1,528,450.
an of supplying sufficient water from Lake Michigan to make a
n of the Illinois river suitable for the largest class of steam-
thout the intervention of dams and locks, has received consid-
tention; but this plan is for reasons which will be hereafter

1st. Channel, 160 feet wide; fall per mile, 1.11 foot; velocity, 2.43 miles per hour.

2d. Channel, 200 feet wide; fall per mile, 0.69 foot; velocity, 1.93 mile per hour.

3d. Channel, 350 feet wide; fall per mile, 0.22 foot; velocity, 1.104 mile per hour.

It would appear, then, to obtain the requisite supply of water from the lake, without excavating a wider channel than we have recommended, that it would have to be about 30 feet deeper opposite to the present lock No. 1 than at present, or 10 feet deeper than the bed of the Des Plaines river, opposite the town of Lockport. It would increase the depth of excavation for the first 10 miles above this point an average of 25 feet; and although the average depth below the bottom upon the plan we propose would, of course, be much less through the earth excavation, the difficulty of executing the work would be increased in a much greater proportion than the depth. By diminishing the declivity, and therefore the depth, as suggested for channels "second" and "third," the width of the canal would be so greatly increased that there would be no great difference in the cost which, upon either plan, would exceed by more than $20,000,000 the cost of the improvement which we recommend. And the only object to be gained by this large additional expenditure would be the saving, at most, of four or five additional dams and locks on the Illinois river.

As the current would be very considerably accelerated, the value of the improvement for navigation would be diminished rather than increased. Through a channel of the dimensions which we recommend, all the water can be drawn from Lake Michigan necessary for navigation, for cleansing Chicago river effectually, and sufficient for an immense manufacturing power.

NAVAL AND MILITARY CONSIDERATIONS IN FAVOR OF THE IMPROVEMENT.

In considering the importance of this system of improvement in its military, naval, and commercial aspects, we respectfully invite attention to the following extracts:

The recent confederation of the British American provinces shows the anxiety felt by the English government in their behalf, and must be regarded as a movement in hostility to the people and institutions of the United States. While it does not actually increase the aggregate British strength on our northern frontier, nor in any way encroach upon our territorial rights, it consolidates the policy in regard to canals, as well as other matters, and renders available the entire force of those provinces in any difficulty which may arise between England and the United States. The English are already able, by means of a system of internal canals, to pass gun-boats of nine feet draught into Lake Erie and Ontario, and are contemplating a new canal which will enable them to reach Huron without coming in reach of American territory at any point. The canals already finished were constructed avowedly for military as well as commercial purposes, and in case of war will enable the English to drive our commerce from the lakes and destroy or lay under contribution nearly every important city on our northern frontier. But, in addition, they can inflict upon us a still more vital injury, when they have gotten possession of the lakes, by severing the main line of our communication with the east for heavy products.

Now that the act of confederation has become a law, the Canadians themselves will be able, and in fact compelled, to adopt a fixed policy in reference to the extension of their internal canal system, as much for offence in the possible contingency of a war with us as for the purpose of establishing close and safe communication with the remoter portions of their territory bordering upon the upper lakes. In view of what the provinces have done in their separate capacity, it is fair to assume that they will

be neglectful of their opportunities as a united nation, but will at the earliest pos-
date set earnestly to work to enlarge, extend, and perfect their means of reaching
nternal seas upon our northern borders.

e are debarred by treaty stipulations from increasing our naval force upon the
s, until after six months' notice has been given. This may be well enough, since it
s us the expense of building costly vessels and maintaining them in commission
n they are not actually required. But as we have no communication between the
s and the sea-coast suitable for vessels of war, we cannot expect to meet the enemy
anything like terms of equality when the emergency arises. It will not do to
nd upon permanent defences for the purpose of barring the entrance to the lakes,
nfortunately they cannot be so situated nor so constructed as to completely sub-
s the object in view.

ere are but two ways in which we can thoroughly protect our own northern fron-
in times of war, and relieve ourselves of a continuous menace in times of peace.
government must either connect the lakes and the Mississippi river by a canal of
ient capacity to accommodate gun-boats suitable for service on the lakes, or pre-
for the annexation or conquest of Canada. As a military measure, the construc-
of a canal will be effective, and fortunately for the country this can be done at an
nse which must be regarded as insignificant when compared with the objects to
btained. But great as are the military reasons which favor the establishment of
nboat navigation between the lakes and the Mississippi, they are vastly tran-
led by those of a commercial and political character. The lakes, the St. Lawrence
, and the New York canals are the natural outlet for the lake cities and a great
on of our northwestern territory, as much as the Mississippi river is the outlet for
erritory contiguous to it. Since the construction of the St. Lawrence and New
canals, the commerce of the northwestern and western States has gradually been
ing its way to the eastern seaboard rather than the southern. Indeed, the north-
ier of our States, even as far west as the Missouri, owe their prosperity, if not their
ence, to the development of water communication with the east. Railroads have
ted a potent influence in populating these States, but their extraordinary develop-
t in wealth and industry is mainly due to the construction of the Canadian and
York canals, by which, up to the present time, they have been able to send their
lus products directly and cheaply to market. This accounts satisfactorily for the
rior wealth of the country bordering directly upon the lakes, and for the marvel-
growth of the cities which have sprung into existence along our northern borders
in the last 40 years. But owing to various restrictions, and to the influence of
ain commercial laws, it has been found unprofitable and inconvenient of late to use
St. Lawrence canal, while the New York canals are already overtaxed, and the
n west of Chicago is almost entirely unprovided with canal facilities worthy of
ame. So that a great part of the people of Illinois, Iowa, Wisconsin, Minnesota,
Missouri, are compelled to send their surplus products to market by rail or perilous
navigation, and at an expense in money or time which leaves them scarcely a
of their value to pay for the cost of production.

ese States have now reached a stage in their development when cheap and direct
nunication with the markets of the world has become an absolute commercial
sity, and unless the amplest provision is made by our own government for such
nunication, and a policy adopted by Canada which shall give us all the advan-
s of unrestricted trade upon their rivers and canals, our commerce and agriculture
be crippled before the expiration of another decade to such an extent as to demand
nly the enlargement of the Illinois and Michigan canal, the improvement of the
ois river, and the construction of the Rock River and Green Bay canal, but the
lute conquest or annexation of the entire dominion of Canada.

the people of our race nothing is more inexorable than a commercial necessity,
gument is so potent as that based upon physical fact, and no ethics so rapidly
rstood as those which relate to the national welfare.

hen our people have been brought to thoroughly understand this necessity, the
which underlie it, and the manner in which it affects their material well-being,
will not be over-nice in regard to the territorial rights of those who bar the door
e eastern market, but will demand the extension of our borders so that their com-
e may find its way unvexed to the sea by the St. Lawrence, as it now does by the
issippi.

has been truly said, it should be a settled principle of American legislation to
urage, in every possible way, facilities for intercommunication, to repress in the
effectual way anything that might possibly act as a restraint.

perience shows us that travel and transportation increase as their cost dimin-
. Whatever, therefore, operates as a tax on locomotion is inconsistent with the
est principles of state policy.

hen the railway system was first being developed in England, measures were
n to give to the government an effectual and thorough control over it. Already in

that country it is agitated to consummate those measures by the state assuming the proprietorship of the roads, equalizing their rates of charge, and reducing those rates to a minimum.

There can be no doubt that such a consummation would produce very powerful social effects.

In America transportation at the lowest possible cost assumes the attitude of an affair of the highest state necessity.

By increasing the facilities for the transportation of manufactured goods and the staple products, we must inevitably increase the necessity for rapid communication between all sections.

By constructing canals and improving river navigation, we necessarily increase the demand for railroads.

ORDER IN WHICH THE IMPROVEMENT SHOULD BE MADE.

Having fully considered the arguments for and against the plan of improvement recommended herein, the question naturally presents itself in this part of our report, what part of the improvement should be first commenced? In view of the fact that there is already an excellent line of canal navigation ending at La Salle, which can be used in its present condition, we are of opinion that the Illinois from La Salle to its mouth should be first improved.

The liberal appropriation of lands by the United States, in 1827, to aid the State of Illinois in the construction of the canal from Lake Michigan to La Salle, and the subsequent expenditures of the State to accomplish the object, amounting to no less than $6,500,000, were based upon the supposition that the Illinois, below La Salle, was a good navigable river, and this large expenditure for the construction of the present canal would secure a good and cheap navigation between Lake Michigan and the Mississippi. Such is not the fact. There has been scarcely a season since the canal was completed, 20 years ago, when there has not been a serious interruption to navigation, for a greater or less period, from low water in the river, and as the country has improved, so that the surface water which formerly drained more slowly and continuously into our rivers has ceased to afford any considerable supply in summer, the evil has been becoming worse. The past season the navigation between La Salle and Peoria was almost suspended from the last of June to the close of navigation, and below this it was but little better. In fact, navigation was virtually suspended on the river for all practical purposes for about five months.

This uncertainty of river navigation has so seriously operated against the canal as to materially diminish its usefulness and revenues. In fact, instead of being a connecting link in our extensive chain of navigation, as it was designed to be, has become little more than a local work, accommodating the limited country along its borders.

The improvement of the Illinois river below La Salle, which we earnestly recommend at the earliest practicable period, would make a perfectly reliable navigation from Lake Michigan to the Mississippi, and whilst it would give a first class navigation, equal at least to that of the lower Mississippi, for an extent of more than 220 miles, it would make even the present canal an important channel of commerce, though not equal in capacity to what is desired. This improvement is estimated to cost $1,953,600, and no improvement contemplated within our knowledge would accomplish equal results at anything like such an expenditure. We recommend an appropriation to the amount above stated.

CANAL CONNECTING ROCK AND ILLINOIS RIVERS.

The importance of the improvement which we have surveyed and estimated is greatly enhanced by the fact that surveys have demonstrated the entire practicability of a canal from the Illinois river, at or near the mouth of the Bureau, to the Mississippi, at or near Rock Island. The length of the canal would be about 64 miles, and it would be supplied with water by a navigable feeder 38 miles in length from Rock river, at Dixon.

For a canal 60 feet wide and six feet deep, the cost, together with that of the feeder, has been estimated at $4,600,000, and it would not probably exceed that sum, whilst it would secure a cheap and direct navigation to the lakes, and a choice of markets to all the country drained by the upper Mississippi and its tributaries.

For estimating the cost of the proposed improvement, it may appropriately be divided as follows:

1. From Chicago to the first lock at Lockport, including what is known as the Summit division of the canal, 29 miles	$11,249,173 98
2. From lock No. 1, at Lockport, to lock No. 8, at the head of Lake Joliet, in Des Plaines river, 7 miles	2,095,546 53
3. From lock No. 8 to Marseilles, all in river except short canals at locks and dams, 40 miles	1,296,806 77
4. From Marseilles to Ottawa, 6 miles	938,380 75
5. From Ottawa to La Salle, all in river except short canal at dam, 17 miles	683,734 53
6. From La Salle to mouth of river, 223 miles	1,954,600 00
Total	18,217,242 56

A condensed history of the present Illinois and Michigan canal, together with many interesting facts in regard to the country through which the enlarged system of navigation will pass, are more fully set forth in the appendix, and sub reports herewith submitted. For a statement of the commerce and navigation to be benefited by this improvement, and a description of the Canadian and New York canals, we call the attention of the department to the report of General Wilson, dated February 17, 1867.

Detailed maps on a large scale, together with descriptive memoirs of the surveys by Engineer Assistants Ulffers, Keefer, and McMath, will be submitted as soon as they can be prepared.

Very respectfully, your obedient servants,

JAS. H. WILSON,
Lieut. Col. 35th Infantry, Brevet Major General U. S. A.
WM. GOODING,
United States Civil Engineer.

Brevet Major General A. A. HUMPHREYS,
Headquarters Corps of Engineers, Washington City, D. C.

APPENDIX A.

Very soon after Illinois became a State, steps were taken to secure the construction of a canal "between the navigable waters of the Illinois river and Lake Michigan," and as early as 1822 Congress authorized the State "to survey and mark through the public lands of the United States the route of the canal connecting the Illinois river with the southern bend of Lake Michigan;" and 90 feet of land on each side of said canal was reserved from sale for canal purposes. This reserve was doubtless made mainly for the purpose of future enlargement, as it was not to be supposed that the State, in its infancy, would make an improvement of sufficient capacity to meet the wants of the country when its resources should be developed.

A board of commissioners was appointed and instructed to have the route of the canal surveyed and the cost of the work estimated, and report the same to the legislature. In 1825, five plans and estimates were submitted by the commissioners, the estimates varying from $639,000 to $716,000.

In 1827 Congress granted to the State of Illinois every alternate section of land lying within five miles of the contemplated canal on each side, the grant amounting to about 284,000 acres.

In 1842 an additional grant of lands, amounting to 5,760 acres, was made in lieu of lands sold by the United States within the limits of the original grant before the location of the State had been approved.

In 1854 an additional grant of lands for the same object was made by Congress, consisting of over 32,000 acres, it having been determined that the State was entitled to more lands by this amount than were selected under the act of 1827.

It will be thus seen that Congress has, by successive acts, through a long series of years, recognized the importance of the Illinois and Michigan canal.

In 1829 a new board of canal commissioners was authorized by the State legislature to commence the construction of the canal, and to dispose of the lands granted by Congress to provide means to carry on the work. In 1830 surveys were made by a party of engineers acting under the orders of the War Department. Their investigations, however, were mostly confined to the practicability of the canal, supply of water, &c.

In 1833 other surveys and estimates were made under the authority of the State, and the engineers estimated the cost of construction of a canal, 40 feet wide and four feet deep, at $4,043,000.

It was not, however, until 1836 that efficient measures for the prosecution of the work were adopted. A new board of canal commissioners was then organized, with authority to construct the canal, Mr. William Gooding appointed engineer, an accuate survey made, and estimates furnished by him of the probable cost of a canal 60 feet wide at surface, 36 feet at bottom in earth excavation, and 48 feet in rock, and six feet deep.

The estimate of the entire cost of such a canal was $8,654,000. Portions of the work were put under contract in June of that year, and fair progress was made on the whole line until 1841, when, for the want of adequate means on the part of the State, the work was gradually suspended until March, 1843, when all operations ceased.

In February, 1843, the law under which the canal was completed by the board of trustees, known as the "trust law," was passed, and the canal finished and brought into use in the spring of 1848. It was not, however, until July, 1845, that any work was done under that law.

The capacity of the canal, as completed by the canal trustees, is the same as that upon which it was commenced in 1836, but the plan of the summit division was changed, to bring the cost within the means provided for its completion. The original plan was to cut down the summit between Lake Michigan and Lockport, and draw through this "deep cut" a supply of water from the lake sufficient for canal purposes. Instead of this the present canal was finished for about 26½ miles on a level averaging nine feet above the original bottom, and water supplied for the summit by the Calumet feeder, 16½ miles long, and by pumping works at Bridgeport, which, the present excessively dry season, have furnished the main supply from Chicago to Channahon, some 45 miles.

The abandonment of the original plan of the "deep cut" also involved the necessity of constructing the Kankakee feeder, which is received into the canal just above the junction of the Kankakee and Des Plaines river.

The amount of money expended in the construction of the present canal, its feeders, and appendages, is as follows:

By canal commissioners, (from 1836 to 1843).....	$4,979,903 74
By canal trustees, (from 1845 to 1848).....	1,429,606 21
Total.....	6,409,509 95

SURVEY OF ILLINOIS RIVER.

Tabular estimate to accompany the report of the survey of the Illinois

EASTERN DIVISION—BRIDGEPORT TO LOCKPORT.

Mile.	EARTH.						ROCK.		
	Under-water excavation.	Price.	Amount.	Common excavation.	Price.	Amount.	Under water.	Price.	Amount.
	Cub. yds.			*Cub. yds.*			*Cub. yds.*		
1st–29th	647,000	$0 55	$355,850	10,967,778	$0 50	$5,483,889 00	240,000	$2 16	$518,400 00

MIDDLE DIVISION—LOCKPORT TO UTICA.

30th				140,761	30	42,111 30			
31st				145,777	30	43,733 10			
32d				168,889	30	50,666 70	11,851	1 75	20,739 25
33d							78,000	1 75	136,500 00
34th				10,000	30	3,000 00	65,000	1 75	113,750 00
35th									
36th				52,731	25	13,182 75			
37th				158,194	25	39,548 50			
38th–41st									
42d									
43d–53d									
54th									
55th–61st									
62d									
63d–75th									
76th				151,467	25	37,866 75			
77th				281,351	25	70,337 75			
78th				115,175	25	28,793 75			
79th				148,861	25	37,215 25			
80th				176,232	25	44,058 00			
81st				158,011	25	39,502 75			
82d				32,300	25	8,075 00			
83d–91st									
92d				89,316	25	22,329 00			
93d				125,001	25	31,250 25			
94th				70,446	25	17,611 50			
95th				109,108	25	27,277 00			

WESTERN DIVISION—UTICA TO THE MOUTH OF ILLINOIS RIVER.

96th–122d									
123d									
124th–186th									
187th									
188th–246th									
247th									
248th–275th									
276th									
277th–317th									
318th									
219th–322d									

SURVEY OF ILLINOIS RIVER.

river improvement made during the summer and autumn of 1867.

EASTERN DIVISION—BRIDGEPORT TO LOCKPORT.

ROCK.			STRUCTURES.						PROTECTION OF RIPRAP.
			Road bridges.		Dams.		Locks.		
Common excavation.	Price.	Amount.	No.	Amount.	No.	Amount.	No.	Amount.	Amount.
Cubic yards. 2,440,319	$1 20	$2,928,382 80	5	$75,000 00	....	.....	.....	.....	$400,000 00

MIDDLE DIVISION—LOCKPORT TO UTICA.

10,000	1 30	13,000 00	....	.....	....	.....	1	$150,000 00	.....
.....	.....	.....	....	.....	....	.....	2	150,000 00	.....
.....	.....	.....	....	.....	....	.....	3 & 4	300,000 00	.....
.....	.....	.....	....	.....	....	.....	.....	.....	.....
.....	.....	.....	1	15,000 00	....	.....	5	175,000 00	.....
171,772	1 30	223,303 60	1	15,000 00	....	.....	.....	.....	.....
82,963	1 20	99,555 60	1	15,000 00	...	.....	6	140,000 00	.....
.....	.....	.....	....	.....	....	.....	7 & 8	280,000 00	.....
.....	.....	.....	....	.....	....	.....	.....	.....	.....
.....	.....	.....	....	.....	3	$49,900 00	9	151,000 00	.....
.....	.....	.....	....	.....	....	.....	.....	.....	.....
.....	.....	.....	....	.....	4	104,000 00	10	206,800 00	.....
.....	.....	.....	....	.....	....	.....	.....	.....	.....
.....	.....	.....	....	.....	5	58,000 00	11	143,480 00	.....
.....	.....	.....	....	.....	....	.....	.....	.....	.....
.....	.....	.....	....	.....	....	.....	.....	.....	10,000 00
.....	.....	.....	....	.....	....	.....	.....	.....	20,000 00
.....	.....	.....	....	.....	....	.....	.....	.....	20,000 00
.....	.....	.....	....	.....	....	.....	12	190,000 00	20,000 00
.....	.....	.....	....	.....	....	.....	13	160,000 00	20,000 00
.....	.....	.....	....	.....	....	.....	.....	.....	20,000 00
.....	.....	.....	....	.....	....	.....	14	161,000 00	15,000 00
.....	.....	.....	....	.....	....	.....	.....	.....	.....
.....	.....	.....	....	.....	7	100,000 00	.....	.....	20,000 00
.....	.....	.....	....	.....	....	.....	.....	.....	20,000 00
.....	.....	.....	....	.....	....	.....	15	170,000 00	20,000 00
.....	.....	.....	....	.....	....	.....	16	150,000 00	20,000 00

WESTERN DIVISION—UTICA TO THE MOUTH OF ILLINOIS RIVER.

.....	.....	.....	....	.....	....	.....	.....	.....	.....
.....	.....	.....	....	.....	8	80,000 00	17	240,000 00	.....
.....	.....	.....	....	.....	....	.....	.....	.....	.....
.....	.....	.....	....	.....	9	58,500 00	18	240,000 00	.....
.....	.....	.....	....	.....	....	.....	.....	.....	.....
.....	.....	.....	....	.....	10	61,500 00	19	235,000 00	.....
.....	.....	.....	....	.....	....	.....	.....	.....	.....
.....	.....	.....	....	.....	11	90,000 00	20	240,000 00	.....
.....	.....	.....	....	.....	....	.....	.....	.....	.....
.....	.....	.....	....	.....	12	195,000 00	21	330,000 00	.....
.....	.....	.....	....	.....	....	.....	.....	.....	.....

SURVEY OF ILLINOIS RIVER.

Tabular statement to accompany the report of the survey, &c.—Continued.

Miles.	Miscellaneous.	Amount.	Total.
	EASTERN DIVISION--BRIDGEPORT TO LOCKPORT.		
1–29	1,500,000 cubic yards of spoil bank, at 20 cents..	$300,000 00	
	Inlet and pivot bridge	60,000 00	
	Spills, culverts, and recess pools	10,000 00	
	Regulating weir	75,000 00	
	Grubbing and clearing	20,000 00	
	Total		$10,226,521 80
	MIDDLE DIVISION—LOCKPORT TO UTICA.		
30			205,111 30
31	Weir, &c	4,000 00	197,733 10
32			371,405 95
33			136,500 00
34	Guard-lock	140,000 00	454,250 00
	1,500 cubic yards of vertical wall, at $5	7,500 00	
35	5,000 cubic yards of vertical wall, at $5	25,000 00	272,303 60
	15,000 cubic yards of embankment, at 60 cents..	9,000 00	
36			267,738 35
37			319,548 50
38–41	No local expenditure.		
42			200,900 00
43–53	No local expenditure.		
54	Short canal	98,320 00	409,120 00
55–61	No local expenditure.		
62			201,480 00
63–75	No local expenditure.		
76			47,866 75
77			90,337 75
78			48,793 75
79			247,215 25
80			224,058 00
81			59,502 75
82			184,075 00
83–91	No local expenditure.		
92			142,329 00
93			
94	20,000 cubic yards of embankment, at 30 cents..	6,000 00	213,611 50
95	54,000 cubic yards of embankment, at 30 cents..	16,200 00	213,477 00
	Total		4,558,607 80
	WESTERN DIVISION—UTICA TO THE MOUTH OF ILLINOIS RIVER.		
96–122	No local expenditure.		
123			320,000 00
124–136	No local expenditure.		
137			298,500 00
138–246	No local expenditure.		
247			302,500 00
248–275	No local expenditure.		
276			330,000 00
277–317	No local expenditure.		
318			525,000 00
319–342	No local expenditure.		
	Total		1,776,000 00

RECAPITULATION—EASTERN DIVISION.

Bridgeport (Chicago) to Lockport, 29 miles	$10,226,521 80
Middle division—Lockport to Utica, 66 miles	4,558,607 80
Western division—Utica to mouth of Illinois river, 227 miles	1,776,000 00
Ten per cent. additional for contingencies	1,656,112 96
Total	18,217,242 56

Style of navigation: Eastern division—independent canal, 29 miles. Middle division—independent canal, 18 miles; slackwater, 48 miles. Western division—slackwater, 227 miles. Total miles of independent canal, 47; total miles of slackwater, 275; total miles of improvement, 322.

H 14.

LOCKPORT, ILLINOIS, *December*, 1867.

GENTLEMEN: Having been intrusted by you with the surveys in detail, to the conduct of which you were appointed by the engineer department of the United States, under the order of the Secretary of War, bearing date May 8, 1867, being "surveys and examinations," and the preparation of "plans and estimates for a system of navigation by way of the Illinois river, between the Mississippi and Lake Michigan, adapted to military, naval, and commercial purposes, in accordance with the act of March 2, 1867," I have the honor to report as follows:

On the 19th of June last, I placed a party of engineers on the south branch of the Chicago river at Bridgeport, a suburb of Chicago, which party continued in the field until late in November, having entered the valley of the river Des Plaines at a point seven miles from the place of beginning, and followed the valley of that river, and the Illinois river to the foot of Grand island, in the last mentioned stream.

On about July 1st I placed another party in the field, which, having carefully examined the head of Lake Michigan, and the waters and water-sheds surrounding it on the southwest, traversed instrumentally the valley of the Kankakee from Momence to its junction with the Illinois, and surveyed, as high up as Aurora, the valley of the Fox river, a tributary of the Illinois, finished their labors by a careful survey of the valley of the Illinois from the foot of Grand island, before mentioned, to the river Mississippi.

The country embraced in this survey has been examined before by various authorities, but so large an amount of information has never been heretofore obtained under one surveillance.

It is believed that the location of the great work contemplated by these examinations has been finally ascertained.

If the left bank, or western bank, of Lake Michigan be examined from its head to its confluence with the upper great lakes, the lowest depression in that bank will be found southwest from Chicago, at a distance of about 17 miles from the city, or rather from its Bridgeport suburb, and forming the opening through which the river Des Plaines, one of the constituent branches of the Illinois, finds its way to its junction with that stream.

This depression is in elevation scarcely more than ten feet above

the average surface of Lake Michigan, and the pass formed by it is not more than a quarter of a mile in width. The ground immediately rises, both north and south of it, and very soon attains an of elevation 100 feet, rising with the distance measured from the axis line of the opening.

Singularly enough, this place is called the "Sag," an expressive definition of its character, although the name is derived from Sangenash, an Indian chief, who distinguished himself in this region in the times gone by—such at least being one of the early traditions of the country.

It is this feature in the physical geography of the country that gave Chicago its importance amongst the aborigines, and attracted the early whites to the same point. It is this which gives Chicago its permanent importance. This little "sag" is the gate to the back country through which the Indians in the old time used to portage their bark canoes, through which the white man will float his ships of a thousand tons. The excavation necessary to produce this last result is nowhere greater on the average than 18 or 19 feet in depth between Chicago and the valley of the Des Plaines, a short distance above Lockport, where the lake level runs out; and such an excavation places Lake Michigan as a reservoir at the command of the engineer.

I am aware that the term "sag" is applied to the country east of this gateway, and to the stream now doing duty as the Calumet feeder. I apply it to the narrow pass in the valley of the Des Plaines, a little east of Lemont, which can be approached from Lake Michigan by two routes, one occupied now by the Illinois and Michigan canal, the other by the Calumet feeder from Blue island.

The Calumet feeder route was examined and sounded under my direction during the progress of this survey, and the necessity for rock excavation developed by those soundings to an extent sufficient to preclude the selection of that route for the enlarged canal. An additional objection is found in the exceedingly crooked approach to Blue Island from the lake by the way of the Calumet river, and there exists no lake harbor of capacity and safety at all commensurate with the objects before us at or near Calumet, the mouth of the Calumet river.

Of the three great lines of navigation that can be brought into practical use connecting the Mississippi with Lake Michigan, the line by the Illinois, namely, the line by the Rock river, and the line by the Wisconsin river, the first of these, the work before us, possesses the prominent advantage that there is no ascending lockage between the lake and the Mississippi waters, whilst hundreds of feet of such lockage is required for both the other lines; and when it is simply stated, in addition, that this great work, commencing at the head of Lake Michigan, ends nearly opposite the mouth of the Missouri, thereby completing a system of inland navigation thousands of miles in extent—when it is stated further, that at one end of this work stands the city of Chicago, and at the other the city of St. Louis, and that between these termini lie "immeasurably spread" plains equaling in fertility any that the sun elsewhere shines upon—surely it is not necessary to say more to infer its importance for "military, naval, and commercial" purposes, especially when it is finally stated, as it now is with entire confidence, that a work can be constructed "on this line" over which the largest commercial, military, and naval vessels now using the upper Mississippi can freely pass to the harbor of Chicago.

In the present state of ship architecture it would appear to be impossible to make the navigations of the lakes and the Mississippi homogeneous. Seven feet depth is the greatest minimum that the upper Mississippi ever can furnish, and large vessels of such light draught

cannot navigate safely the great lakes or the ocean, except the naval vessels of the monitor class. Should, however, invention in this art ever overcome this difficulty, vessels for all purposes may pass indifferently through the magnificent internal navigation of this continent, and through every navigable sea on the earth's surface. Until that period arrives the points of lake connection on navigations between the Mississippi and the lakes, like Chicago, for instance, must remain transshipping points. With the wonderful facilities for unloading, furnished by the elevators and kindred inventions, transshipment has ceased to be the difficulty or cause of expense and retardation that it was in former time.

The surveys made by us around the southwestern branch of Lake Michigan settled the question, that through the "Sag" or the Lemont narrows was the only passage towards the west for Lake Michigan waters flowing by gravity; and this being once settled, the remainder of the location of this work becomes inevitable, and must follow the valley of the Des Plaines to its mouth, and thence the valley of the Illinois to the river Mississippi.

We carefully examined the location of the Illinois and Michigan canal from its northeastern terminus at Bridgeport, progressing southwestwardly to Lockport. We examined the sluggish stream, the south branch of the Chicago river or creek, to its head, and the tortuous crooked channel which it has made, and have concluded that no variation from the location of the Illinois and Michigan canal would better the line of the proposed navigation; slight and unimportant variations, for alignment's sake, may be made, but no essential change is necessary or advisable.

The great canal, then, will form three grand divisions of unequal lengths and cost, the division lines being lines of demarcation between the styles of engineering required for each.

The eastern division will consist of a thorough cut in clay and rock about 29 miles in length, the base of which will start at a point on the south branch of the Chicago river at Bridgeport, known to be six feet below the lowest water that has been known in Lake Michigan for thirty years, and from seven to eight feet below average low water, and shall fall at the rate of one-tenth of a foot per mile for a distance of 28 miles. (It is hardly necessary to say that this starting point is in lake navigation.) The first 17 miles of this cut will be in blue drift clay, the last 12 miles in limestone rock, lying in layers nearly level, some of which furnish a very superior building stone, now extensively used in Chicago, and the deepest average cutting in either clay or rock will not exceed 19 feet. This, although the shortest, will be the most expensive of the divisions. The Illinois and Michigan canal was originally planned to be excavated to this base, but the plan was temporarily abandoned by the state of Illinois on account of monetary difficulties. The city of Chicago has recently, however, resumed the deepening process at her own present expense, with the double object of enlarging the navigation and of giving a passage for the sewage of the city, from the sluggish Chicago river to the water-courses which find their outlet in the Mississippi—a plan sanctioned and recommended by a board of civil engineers of the first rank in our country.

The middle division will extend 66 miles from Lockport, on the river Des Plaines, to Utica on the Illinois river, a short distance above La Salle. This will be a mixed navigation composed of slack-water and independent canal, the former preponderating. This division will be second in cost.

The western division will be slack-water exclusively, extending from Utica, a short distance above La Salle, to the mouth of the Illinois, a distance of 227 miles. This, though the longest by far, will be much the least expensive of the divisions; thus the whole work, from lake navigation on the Chicago river to river navigation on the Mississippi at the mouth of the Illinois, will be 322 miles in length.

In explanation of this proposed system, it must be stated that the location of the Illinois and Michigan canal has been of great assistance in determining it. That work, in the thorough cut especially, occupies ground than which, in the county passed over, no better could be chosen, and as has been stated the changes required for the new work are scarcely worthy of enumeration.

Pursuing this work down to its present termination at La Salle, we find that it consists almost entirely of independent canals. Were a single enlargement, say to the size of the Erie canal, or even considerably beyond that capacity, at present in question, I should have no hesitation in recommending a close adherence to the present line, because for a work of its size it is admirably located, entirely out of the way of freshets and ice gorges, at the same time showing great directness of alignment.

But in proposing an enlargement like the present, where all the excavations and culverts, and aqueducts and bridges, are to be quadrupled in size, the avoidance of expense becomes an indispensable element in the calculation. Therefore when the stream along which the work passes offers facilities for a slack-water improvement, such offer cannot well be rejected, as a single work, a single expenditure at one point in this style of improvement, creates a navigation extending sometimes over many miles, in which no expense is necessary either for construction or maintenance.

The objection to the slack-water system here is, that in times of freshets and ice gorges, the works in the stream are exposed to the forces brought into play during such periods, whilst its advantages, in calm times, consists in presenting wide and capacious bodies of water facilitating navigation to a very high degree, to which must be added the very important saving in cost.

The advantage of the independent canal, in this particular case, is its immunity from danger from very high floods. Its disadvantages are, its confined channel and its far greater cost.

It might further be cited against the slack-water system, that its effect is to drown out lands which otherwise might be cultivated with advantage. It is, however, a peculiarity of this river that no system of dams can be practically erected in its valley which will add to the extraordinary elevation which the floods now attain. Dams in this river must be built with the expectation that they will occasionally be overflowed by a volume of water on the surface of which they will scarcely be of sufficient height to raise a ripple. Navigation below La Salle will, every season, be found in a plane so far above the works, that vessels will pass over them as freely as if they did not exist, and when this is not the case, namely, when there happens to be considerable comparative fall in the river, this fall can be taken advantage of, so that damage from their refluent water will be reduced to the minimum, in fact, to be scarcely susceptible of being demonstrated as caused by the erection of the dams.

The weight of the extra cost of the independent canal system here has no alleviation, except that it is an insurance against floods.

The discrepancies in cost between the two systems are not so great in a small canal as they are in a large one, one reason for which is that the

cost of a dam remains unchanged for a work of either size; and thus if, as has been stated, this work were to be retained at its present size; the independent system might well be adhered to. But where the works assume a magnitude including facilities for military and naval purposes, the additional cost, amounting here to millions, operates conclusively against the independent canal work.

Almost immediately after leaving Lockport, then, going west, the river begins to offer itself for consideration; no less than three ways of passing through Joliet preparatory to entering the bed of the stream are presented.

The first of these is to adhere to the old location until having passed Joliet. The canal veers to the left and enters Lake Joliet on the right bank of the stream, between three and four miles below the town.

The second, just before the line reaches a point opposite the State penitentiary, turns to the left, passing the penitentiary quarries, and, following through the cultivated lands immediately in front of the bluffs or terraces bounding them on the south, crosses Hickory creek by an aqueduct, and enters Lake Joliet about two miles below on the left bank of the stream.

The third leaves the present line almost exactly opposite the penitentiary, and following a depression to the left of the more thickly populated parts of Joliet, crosses Hickory creek, and joins the second line above its entrance into Lake Joliet.

All these lines are practicable, and have arguments for and against them which need not be recapitulated here.

The first line is here chosen for estimate, for that it keeps the canal and its business in their present locality, and disturbs values and properties the least of any of the three.

When the canal comes to be constructed it will be time enough to discuss the various arguments *pro* and *con* to grow out of this subject.

At Lockport, then, and until Joliet is passed, the line remains as it is now, except that it is to be enlarged. At Lockport occurs lock No. 1, and about a mile below, lock No. 2, then locks 3 and 4, which latter drops into the Des Plaines as it enters Joliet. Then occurs dam No. 1 and lock No. 5, lift and guard, which drops into the basin of dam No. 2, built across the Des Plaines in the heart of the town. Here occurs guard-lock No. 1, which admits navigation to a piece of independent canal, extending from this point to Lake Joliet. Locks 6, 7, and 8 occur on this piece of independent canal. After passing dam No. 2, the bed of the stream has to be changed to the left, and provision is made in the estimate for a new channel in the rock from 6 to 8 feet deep, 200 feet wide, and about half a mile long. This plan avoids the necessity of disturbing buildings to any considerable extent, and creates a commodious basin for the business of the town, where, from the crowded appearance of things at present, there did not seem to be much promise of such facility. At about a quarter of a mile west of the first road-bridge now crossing the canal below Joliet the line veers to the left, leaving the present canal, and by a very direct course enters Lake Joliet at the foot of the low limestone bluffs which border the river at the head of Lake Joliet on the right bank of the stream.

Lake Joliet is slightly raised by the refluent water of dam No. 3 crossing the river about a mile below Treat's island. A short independent canal conducts us around dam No. 3 into the water backed up by dam No. 4, which is to be constructed on the Illinois river, a short distance below Dresden. A spill must be given to this dam somewhat greater than ordinary, for at the confluence of the Des Plaines and the Kanka-

kee there is a tendency to ice gorges, the effects of which must be guarded against. The canal around it must be located in such a way as not to attract currents, for it is difficult to build works which will withstand the forces of an ice gorge or freshet when in full activity. It is difficult to predict now what the fullest consideration may eventually dictate as the true construction here. Independent canal is easy to construct from Joliet to this point, and below Dresden might very safely enter the river, but it would be very costly. Twelve or fifteen miles of excavation, over 100 feet wide and 8 or 10 feet deep, much of it in rock, an aqueduct across the Du Page, and bridges and culverts lengthened in proportion, besides much additional and expensive protection required at the Channahon bluffs, present a formidable bill of expense, which, unless the most mature investigation of the probable results of ice gorges below Dresden should result in a well grounded fear of frequent destruction of the river works, ought hardly to be incurred. I have concluded to recommend the slack-water, and have so estimated the cost of the line, in the hope that a careful and prolonged study of the locality and the regimen of the Illinois will warrant eventually the correctness of this choice.

Entering the stream again below the Dresden dam No. 4, we have slack-water to a point about two miles below Morris, where dam No. 5 is to be erected, which lets us down into the pool of the Marseilles dam, recently erected for manufacturing purposes. This dam we number in our series dam No. 6. At Marseilles independent canal is indicated on account of the considerable fall occurring just below that town, and continuing nearly to Ottawa, a portion of the river named from the circumstance, by the French, "The Grand Rapids." We enter the river permanently, however, for slack-water, a short distance above Ottawa, where the refluent water of dam No. 7, to be constructed at or near Starve Rock, forms our navigation until we reach Utica, where we enter upon the western division, comprising the remaining 227 miles in length of the Illinois, on which there is found to be a fall not exceeding 29 feet.

This long stretch is very well described in Mr. Abert's report to General Wilson on this same subject, laid before Congress last year. Suffice it to say here, that the Illinois river, from Utica to its mouth, flows in a bed of alluvion, sand, gravel and clay, irregularly alternating.

Through this bed the river has made a passage for itself, averaging from 10 to 12 feet in depth, in a plane tangential to the shoals, and some 600 to 800 feet in width.

This is the state of things presented at low water, but in high water the river overflows this channel, and covers the alluvial intervale or bottom land to the depth of 10 or 12 feet. The intervale, in its turn, is bounded by terraces or bluffs, in elevation, say, from 60 to 100 feet and more above low water, forming a second valley, which varies in width from a mile and a half to six miles.

This whole surface during the high-water periods is covered with water to a depth of from 4 to 10 and 12 feet.

It is evident that with a fall scarcely exceeding an inch and a half per mile, there must be most effective navigation upon this whole stretch when the floods prevail; and it will scarcely be believed when it is stated that, notwithstanding this vast accumulation of water, and the very gentle inclined plane that carries it away, the depths are reduced almost every season upon the shoals in the bed of the stream, until they do not exceed an average depth of 20 inches, thus in fact suspending navigation for periods varying from 60 to 90 days, and extending sometimes, as in the season last past, to a period of 150 days.

system of dams, whose top surfaces shall be in a plane of water seven feet in depth upon the shoals of the river, with open a less area in width than the area of the navigable thorough proposed to be made from Lake Michigan. The last of the that going into the Mississippi, to have, instead of an open egular lock.

it of these plans is the one best understood by that portion of conversant with systems of internal navigation. It is certain ration, and will not cost more than $9,000 per mile of naviga- created by it. It cannot fail of the proposed results if prop- ructed.

ond, third, and fourth, though all of them cheaper than the ll of them more or less experimental.

t of these systems is therefore chosen, recommended, and esti- his report; leaving the others for consideration if they should l worthy of it in comparison with the chosen one, when the constructing this great work shall have arrived.

n Utica, then, and the mouth of the river, being the western f this canal, it is proposed to erect five dams, being dams No. 12 inclusive, and by the side of those dams lock No. 21 inclusive, with only so much independent canal as will navigation around the abutments of the dams in safety. as will be so constructed as to insure a minimum depth for of seven feet, and to afford facility for passing them on pths of water until the freshet shall rise to a height in which of the dams themselves will not impede navigation, and ves- ver them freely and without grounding.

n navigation at all stages of the water is thus created, and if nal quantity of water brought in from the Lake Michigan feeder be such as to supply the want now so severely felt from n and infiltration during the dry months, the width of the g less than half as great as that of the feeder, and their depth same, whilst the plane of fall is almost exactly equal, it may be ck-gates need not be closed during such periods, and thus a

tion, this magnificent work may prove to be more easily operated than any work now in existence, certainly on this continent, and possibly in the world.

In coming to some of the results above enumerated, we performed some sxtensive field operations.

The Calumet feeder was sounded with iron rods from its outlet to the dam at Blue island. A regular survey was made from Blue island to Momence, on the Kankakee, and from Momence to the junction of the Kankakee and the Des Plaines, where the Illinois river is formed. A reconnoissance was made of the upper Kankakee, from Momence in a northerly direction along the river well into the State of Indiana, say about 30 miles, among the Kankakee marshes, where boats had to be used, there being no foot-holding for the instruments.

This surveying and reconnoitering, although settling the point forever that there is no practicable outlet from Lake Michigan to the Mississippi waters, except the one chosen and reported upon, nevertheless gave rise to suggestions more or less pregnant and important.

It is very certain that a navigation of respectable size can be made from this work at or near the mouth of Kankakee to Momence, thus developing a rich and productive section of the country for a distance of nearly 50 miles, and it is not at all certain but that this navigation can be extended and produced among those Kankakee marshes for a hundred or more miles further, until, indeed, a junction can be effected with the Wabash and Erie Canal, thus producing a smaller canal, but one capable of transporting say a million or more tons per annum to Lake Erie.

I can pronounce with great certainty in favor of the practicability of the work as far as Momence. Its possibilities beyond are only suggested, and cannot be realized without a more careful investigation of that interesting region.

A clearing out and unification of channels, and an occasional cut-off will give a small steamer navigation on a minimum depth of, say, 2 feet for a hundred miles northward of Momence, even as it is. A judicious expenditure of say a quarter of a million would no doubt effect this, and at the same time assist materially in draining that noble body of land; and I hint at the possibility of a four-foot navigation being constructed through that region, which, as has been stated, may be attached to the Maumee work, thus connecting the Mississippi by water with Lake Erie, in a direction favorable to cheap transportation; an immense saving in distance being made as against the passage by the lakes to the same point.

The work from the mouth of the Kankakee to Momence, 47½ miles, can be constructed for $950,000, being at the rate of $20,000 per mile. This for a slack-water navigation, with locks 100 × 17 × 5 feet deep, capable of passing boats of, say, 125 tons. The fall from Momence to the Kankakee feeder is 105 feet, and a gauge of the stream at its mouth on the 9th of September, 1867, an extraordinarily dry period, gave 27,377 cubic feet per minute, including the amount passing through the feeder to the Illinois and Michigan canal. It is proper to say here that the limestone, much pervaded by fissures, over which the Kankakee flows near its mouth, may considerably reduce the visible quantity of water flowing over it; that therefore its contribution to the Illinois may be larger than appears from the gauge, and 30,000 feet per minute may fairly be taken as the minimum of the past season.

The Fox river, also, which falls into the Illinois from the right at Ottawa, was made a subject of examination. A survey of this river commenced

at Ottawa and was carried to Aurora, a distance of 40 miles, measuring from the feeder dam at Ottawa. This river it is entirely practicable to improve by slack-water navigation for that distance, and possibly as far as to its crossing of the State line of Wisconsin, a further stretch of over 60 miles. A navigation of the same size as that proposed for the Kankakee locks, 100 × 17 × 5, would cost, on the Fox river, at the rate of $25,000 per mile. The fall from Aurora to the feeder at Ottawa is 136 feet. The quantity of water flowing on the 17th of September, 1867, a period of great drought, was 31,539 cubic feet per minute, including what passed through the feeder to the canal.

A most important branch line to this great improvement was surveyed by Colonel Hudnutt, of Chicago, in 1866. He reports that a canal can be built of dimensions somewhat larger than the Illinois and Michigan canal, from Rock Island on the Mississippi to the vicinity of Hennepin on the Illinois, a distance of 64 miles, with a navigable feeder from the Rock river at Dixon of 38 miles in length, and that this work can be built for about $4,500,000. I consider Colonel Hudnutt's estimate sufficiently high, and would recommend, if the branch be adopted, that the size of the work be increased so as to correspond with that recommended for the Rock river improvement, in General Wilson's report of 1866, the branch in question being also an important branch of the latter work. The size recommended by Colonel Hudnutt is for the locks 150 × 21 × 6, with a proportionate canal prism. The Rock river lock is 200 × 30 × 7.

A final location of this work and economical construction might decide that the enlarged size recommended here would not exceed $6,000,000 in cost, and would probably fall short of it, and it would be a decided advantage to have this great branch line constructed so as to coincide with at least one of its parent stems.

Its coincidence with the Rock river improvement would raise it to a capacity embracing a very large proportion of the boats on the upper Mississippi, and to a register of at least 500 tons.

A tabular statement of the estimated cost accompanies this report; from this may be deduced the following aggregates:

Eastern division—Chicago to Lockport, 29 miles.....	$11,249,173 98
Middle division—Lockport to Utica, 66 miles.....	5,014,468 58
Western division—Utica to mouth of Illinois, 227 miles..	1,953,600 00
Total.....	18,217,242 56

A smaller sub-division might be made as follows:

1. Chicago to Lockport, 29 miles.....	$11,249,173 98
2. Lock No. 1 to lock No. 8, (Joliet lake,) 7 miles.....	2,095,546 53
3. Lock No. 8 to Marseilles, 40 miles.....	1,296,806 77
4. Marseilles to Ottawa, 6 miles.....	938,380 75
5. Ottawa to La Salle, 17 miles.....	683,734 53
6. La Salle to mouth of the river, 223 miles.....	1,953,600 00
Total.....	18,217,242 56

These sums include contingencies for damages, &c.

The works for this canal are proposed to be plain and substantial structures, and material is attainable for them along the line. Such lumber as may be required from a distance is constantly passing along

the Illinois and Michigan canal and the Illinois river during periods of navigation.

All of which is respectfully submitted.

I am, very respectfully, your obedient servant,

JAMES WORRALL,
Civil Engineer Assistant.

Brevet Maj. Gen. J. H. WILSON, U. S. A., and
WILLIAM GOODING, U. S. C. E.,
Board of Engineers.

H A.

Railroad levee on west side of the Mississippi river.

WILLETT'S POINT, NEW YORK HARBOR,
January 31, 1868.

GENERAL: I have the honor to submit the following report upon the project of the Memphis and St. Louis Railroad Company for building a railroad levee from the mouth of St. Francis river, via the bank of the Mississippi, to New Madrid, and thence north, via Big Prairie, to connect with the Iron Mountain railroad, of Missouri. This project was referred to me by an indorsement from your headquarters, dated January 22, 1868, and was received in full on January 28, 1868. My report is based upon information obtained when your assistant in the surveys and investigations to determine the most practicable plan for securing the alluvial lands of the Mississippi from overflow, made in the years 1857–1861, and in your later examinations and surveys of the levees of the Mississippi, made in 1865–'66.

The following facts and considerations have an important bearing upon any project for reclaiming the bottom lands of the St. Francis river from overflow.

This region consists of a belt of swamp lands and low ridges extending westward from the Mississippi river between Cape Girardeau and the mouth of St. Francis river. It is bounded on the west by Crowley's ridge and other hills high above overflow which extend northward from the mouth of St. Francis river to the highlands west of Cape Girardeau. There is thus inclosed between the Mississippi and this range of hills an elliptical distance about 200 miles long and 35 miles wide. It contains 6,900 square miles, of which at least 600 square miles are entirely above overflow. The remainder is submerged in great flood years to an average depth of about 3 feet. This great ellipse slopes from north to south at an average rate of about 8 inches to the mile; and from east to west at an average rate of about 6 inches to the mile. The St. Francis river washes the western hills. Where it pierces Chalk bluffs its high-water elevation above the gulf is 280 feet; at the crossing of the Memphis and Little Rock railroad, this elevation is 209 feet; at the mouth it is about 200 feet. The corresponding elevation of the high-water surface of the Mississippi is at Cairo 322 feet; at Columbus 310 feet, and at Memphis 221 feet. Of course the general southwestward slope of the bottom lands in this basin would cause the vicinity of the St. Francis river to be the channel of discharge both for ordinary downfall and for Mississippi overflow throughout the entire region. Unfortunately, this is prevented by a system of low ridges, some entirely and some nearly above overflow, which extend, but not continuously, throughout the whole basin, preserving a general north and south direction. These ridges turn much of

overflow back to the Mississippi, and thus render the protection of country far more difficult than that of the Yazoo basin, which is quite ilar in general features, but which differs in this important respect, t water which has once left the Mississippi cannot return except ɔugh or near the mouth of Yazoo river at its southern extremity. › chief bayous which carry the overflow back to the Mississippi from St. Francis basin are the following, viz: James bayou, near Island bayou St. John, at New Meadow; Walker's bayou, near Island 15; l bayou, opposite Island 30; Wappenoky bayou, near Island 40, and ayou near head of Island 46. There is also an immense discharge in sons of great floods from the St. Francis river and over the banks on h side of its mouth extending from Helena to Walnut Bend.

leside the danger of overflow from back water checked in its south- ɪtward flow by swamp ridges, and even the danger of his levees being ıhed into the river in certain localities from the same cause, the engi- r has to contend with a rapid caving of the banks of the Mississippi he fundus of almost all the great bends throughout this distance. It ar worse here than in the lower river. For instance, Council Bend caved a mile and a half in 40 years, and another bend in the same nity has caved over a mile since it was surveyed in 1821.

'he St. Francis bottom lands are of inexhaustible fertility and are able of yielding a bale of cotton to the acre in the southern portion, 60 bushels of corn to the acre in the northern portion. Great induce- ıts are thus offered to protect it from overflow from the Mississippi. hat can be kept out, the natural swamp drains are amply sufficient arry off the rain water. It is, however, clear from the conditions of problem that a thorough general system and great good judgment letails are necessary before success can be reasonably expected. mer attempts have lacked both of these essential elements, as can be ly shown. Under the impulse offered in 1850 by the congressional nt of the swamp and overflowed lands within their limits to the several r States to provide a fund for reclaiming them, a vigorous effort was le, but it was based upon no general plan or knowledge of the topog- hy of the basin or of the laws of river discharge. A little levee, aver- ıg about three feet high, and of inadequate cross-section, was built rly continuously along the river front of the entire St. Francis basin. losely followed every bend of the river, and, as might have been icipated, it proved to be a most inadequate and temporary expedient. › great flood of 1858 and those of succeeding years washed much of way; the caving in of the bends carried miles of it into the river; and, ne, in 1866, the levees below Memphis were virtually destroyed, and se above that city were in a very unsatisfactory condition. The prob- of protection is, therefore, to-day, practically a new one, and work etofore expended should be regarded as nearly useless, except for local rests, and should be neglected in forming any general plan for future rations. Such a plan should be based on the following general con- ɔns:

To locate the levee so far west of the river as to avoid all danger of ing for at least 50 years. Judging by the past, it should therefore be east a mile and a half west of the fundus of each and every bend. It robable that in some places the natural ridges do not favor so great stance, but it is cheaper to expend more money at the outset, and s secure absolute immunity from overflow, than to rebuild any large ion of the levee after a crevasse which, with the back country under ivation, might involve a loss of millions of dollars, to say nothing of reciating the value of lands supposed to be secure.

The work should commence in the *northern* part of the district and

extend southward, not the reverse. By this plan the upper portion of the bottom lands would derive immediate benefit, since the flood waters would flow southerly from the temporary terminus of the work, and would not endanger most of the lands behind the levee already constructed. Moreover, if the levees were begun in the southern part of the basin, the overflow returning from the swamps to the river would give great trouble and might even endanger their safety. Still another reason exists for this method of laying out the work, viz: that any great flood occurring during the progress of construction would furnish a practical test of the sufficiency of the height adopted for the top of the embankment.

3. Close attention should be given during the progress of the work to the subject of the rain water drainage of the land reclaimed. It will probably be necessary to cut drains through some of the swamp ridges, which now turn the combined rain water and Mississippi overflow back to the river. If this matter were not considered, the levees might raise rain water lakes in the rainy months, which would weaken the embankments, and in the event of a flood might even cause their destruction.

4. The most vitally important and the most difficult to determine of all the conditions for a good system of levees is that of their cross-section. The usual rules for river embankments will indicate sufficiently the thickness and the slopes, when the height is fixed. The determination of the *height* is one of the most difficult and complicated problems offered to the hydraulic engineer. In the following solution of this problem for the St. Francis front, I would state at the outset that it is based upon the local observations made during the great flood of 1858, viz: a daily measurement of the discharge of the river at Columbus and at Vicksburg; daily records of the stand of the river at Cairo, Columbus, Memphis, Helena, and several points below, and a careful examination made in the following low water of the crevasses along the front from Cairo south, including all the local information which could be obtained from the most intelligent of the residents, and from all other authentic sources. It is to be remarked that the vast number of breaks in the levees in this district, together with the sudden and excessive oscillations in the sand of the river in this part of its course, where the "wave system" of flood movement is in full force, rendered it impossible to apply the same close mathematical analysis to the problem that was used for the lower river. The conclusions, however, were not hastily formed, but were laboriously deduced from a mass of information of undoubted accuracy, and were subjected to so many incidental checks as to be worthy of confidence even where so great interests are involved. It should be distinctly understood, however, that the engineer in charge of the work must cause the most careful observations to be made upon the river in order to determine the actual effect of his labors upon the floods, and thus to check the computations, holding himself ready to modify his project, if necessary, upon the data thus obtained.

This is not the place to make any detailed demonstration of the method adopted in deducing the requisite heights for the levees in this part of the Mississippi valley. The subject is fully treated in the report of 1861. It is sufficient to state that the water which leaves the river in the northern part of the St. Francis front below New Madrid flows past the middle of the district in the swamps, and if it were confined to the river-bed by a system of levees the high-water mark would be materially raised thereby in this middle part of the region. In the southern part of the bottom lands the increased height will be less from this cause, but it will also be affected by the back-water resulting from reclaiming the swamps below Helena. This whole subject is treated in great detail in the report of 1861, and the following conclusions are there announced:

Had the river been securely confined to its channel by levees in 1858 that great flood would have risen above its actual height about two feet at Columbus, about 6.5 feet at Memphis, and about four feet at Helena. The actual height at Helena was lowered about three feet by the anomalous influence of the immense discharge into the Yazoo bottom in its vicinity. So that if the entire Mississippi lowlands are to be reclaimed from overflow in a flood like 1858—probably the greatest of which we have authentic records—the tops of the levees must be placed three feet above the high-water mark of that year at the mouth of the Ohio, and thence gradually increase this height to seven feet at Osceola, and retain this latter height to mouth of St. Francis river.

In 1862 a great flood occurred, but, unfortunately, the war prevented the preservation of the exact records necessary to compare it with the flood of 1858. The following facts were collected from trustworthy sources in 1865–'66, and are believed to be worthy of confidence: The high-water mark of 1862 was higher than that of 1858 at Cairo by 1.5 foot; at Memphis by 0.6 foot; at head of Cat island by 0.7 foot; at foot of Cat island by 0.7 foot: at head of Walnut Bend by 1.1 foot, and at Helena by 1.8 foot. These facts do not necessarily prove that the flood of 1862 was greater than that of 1858—that is, that the maximum volume entries in the alluvial region in the former was greater than in the latter year. Still, when the estimate was made so closely upon the flood of 1858, prudence would dictate to those having charge of the construction of a grand levee for the entire St. Francis bottom to increase the heights computed for that flood by one foot—that is, to place the top of the levee four feet above the high water of 1858 at the mouth of the Ohio, and to gradually increase this height to eight feet at and below Osceola. I certainly would propose a less height myself as sufficient to secure the country from overflow.

These four main elements of any good plan for the protection of the St. Francis bottom from the ravages of floods furnish the touchstone for judging of the project of the Memphis and St. Louis Railroad Company. In its general features it evidently complies with them, and in addition offers by branch roads, readily to be constructed as needed, the great benefits of direct railroad communication and transportation of crops to the markets of Memphis and St. Louis. By combining the interests of planters and transporters in the security of the levees the safety of the region is doubly guaranteed. By putting the levee to a useful purpose in addition to its passive work of protecting the country, it will better repay the cost of construction, and can be made secure in consequence.

There is one objection which will be made by the proprietors of the lands thrown out by its location, viz: that abandoning so much valuable land to the river is both unjust to them and an injury to the country. This objection should have no weight, because it is covered by the broad principle that the interests of a part must yield to the requirements of the general good. In order to bring the back country under cultivation security against overflow must be had. This cannot be obtained where the levees are near caving bends, as experience has fully shown. Moreover nothing prevents the inauguration of a system of exterior levees to be built by local means, which being of less importance might be made much more cheaply, and yet of sufficient dimensions to afford security against all but the greatest floods, which fortunately are not of very frequent occurrence.

It only remains to determine how the project fulfills each of the four conditions in detail.

1. As to location. The position of the route marked as adopted on the accompanying map is in general good for a levee location, but at most of

the bends it lies too near the river. The map does not indicate any difficulty in curving the line to the westward in these bends, so as to secure a minimum distance of one and a half mile. In my judgment this should be done.

All or nearly all the overflow above New Madrid is returned to the river by the high ridge called Big Prairie, which extending north from that town, is followed by the railroad. The proposed embankment thus affords protection to all the St. Francis bottom except the northeast section and the strip abandoned to the river, say in all about 1,500 square miles. The area protected is therefore about 5,400 square miles. Allowing one-fourth of this region to consist of lakes and cypress swamps too low for natural drainage, we have 4,050 square miles, or about 2,600,000 acres of the best cotton and corn land in the world that will be open to safe cultivation by the proposed railroad embankment. Most of this region is forest land at present, but it can easily be prepared for culture in the usual way, by girdling the trees and burning the underbrush. As upon all alluvial land of great fertility, there will probably be a prevalence of bilious and malarial fevers for a certain period before the country becomes thoroughly reclaimed; but the district lies north of the usual limits for the yellow fever, and no sickness which will prevent the cultivation and rapid settlement of the reclaimed lands need be apprehended.

2. As to order of cultivation. Motives of self-interest will doubtless lead the railroad company to construct the northern part of the road first. Unlike an ordinary firm of levee contractors they have an interest in the work after it is completed, and hence will not expose it to destruction by beginning at the southern end. Moreover the first object will be to connect St. Louis and Memphis.

3. As to rain-water drainage in the reclaimed lands, the same interest in the permanency of the embankment will compel the railroad to cut through any ridge which makes a lake against it in the rainy season. There is no doubt that the natural swamp drains leading to the St. Francis river will carry off all the downfall upon the basin, with, perhaps, some ditching of ridges. The railroad company cannot avoid doing this work when any general interest is concerned. Local drainage of course must be attended to by local interests.

4. As to the height and cross-section of the embankment. It appears from the accompanying letter of Mr. E. H. Porter, president of the company, that the engineer proposes a solid embankment having an average height of 7.5 feet, a width at top of 12 feet, and a slope of five feet to one foot; also that the whole part of the route liable to overflow from the mouth of the St. Francis river to New Madrid is 170 miles in length. The accompanying tracing of the railroad map indicates the location of the road throughout this distance; but the only profile which accompanies those papers is that of the location from Hopefield opposite Memphis to Arkansas and Missouri State line, a distance of 64.26 miles. Upon this partial profile, which, it may be added, indicates many bridges, of course inconsistent with a levee embankment, the grade seems to be fixed by placing it from two feet to four feet (usually about two feet) above the local high-water marks found upon the trees. The average height of the embankment fulfilling this condition seems from a hasty inspection of the draining to be about that indicated above, namely, 7.5 feet. In other words, the top of the levee is placed two feet above the Mississippi high water at Hopefield, Mound City, and Osceola, where the line approaches most nearly to the river bank, but at certain intermediate points is lowered to correspond with the local marks on the

trees; this grade seems to give the proposed height of 7.5 feet to the levee.

If this inference is correct the company has underrated the magnitude of their undertaking in two respects:

1. The construction of the embankment will raise the high-water mark upon it to the same level which it attains upon the river-bank, by damming up the water between the river and the levee. Heretofore it has had free access to the swamps, and hence its surface has had a perceptible slope away from the river. What this slope is, depends upon local conditions, but for a location having an average distance of four miles from the river, my experience in other bottom lands of the Mississippi would lead me to anticipate a difference of levee at least two feet. In fact the profile itself seems to indicate this.

2. The company have overlooked the fact that the construction of the embankment will raise the high water of the river itself. As already seen, this rise, very closely estimated, will be about eight feet between New Madrid and the mouth of the St. Francis. There is no doubt whatever that this effect will be produced, and that this is the minimum amount upon which it would be safe to estimate.

Hence, if I am correct in supposing that the adopted grade is indicated upon this profile and if the company design to allow two feet above probable high water for their grade, their proposed height of embankment must be increased to $2+8=10$ feet; that is, it must become 17.5 feet. I would not venture to recommend a less height. The levees upon the vistula average 20 feet in height.

With respect to the cross-section my opinion is that a width at top of 12 feet, with a slope toward the river of one upon three and a slope toward the land of one upon two, would suffice; provided the embankment is well made, is covered with Bermuda grass, and is protected against the action of currents by a forest growth near its base, between it and the river. The distance of its location from the river and the short deviation of extreme high water in this part of the alluvial region render these deviations safe. They would not be sufficient further south for levees of this height.

In conclusion I would say that in my judgment this plan is the best; in fact, the only feasible one at present for the protection of this region againts river floods and for rendering it available for cultivation. To reclaim the district will be of vast utility to the States of Arkansas and Missouri, and indeed to the whole country. It is to be regreted that so expensive works are required to secure this protection; but it is better to enter upon the undertaking with a proper appreciation of its magnitude than to expend vast sums in abortive attempts, as has heretofore been done in most levee projects in the Mississippi valley.

I am, general, very respectfully, your obedient servant,

HENRY L. ABBOT,
Major of Engineers, Brevet Brigadier General.

Major General A. A. HUMPHREYS,
Chief of Engineers United States Army.

HOUSE OF REPRESENTATIVES,
Washington, January 17, 1868.

GENERAL: A bill has been referred to the Committee on Freedmen's Affairs granting aid by the general government to two railroad companies, one chartered by the Arkansas legislature, and the other by the Missouri legislature, for the construction of a railroad along the west bank of the

Mississippi river from the mouth of the St. Francis to a point west of Cape Girardeau, in Missouri, there to unite with the Iron Mountain road and thus form a continuous line of road to St. Louis. These companies propose to construct the bed of their roads of height and width to serve as a levee.

The committee are desirous of obtaining such information from your department bearing upon the matters involved in these propositions as you can conveniently furnish. They would like to be advised especially as to the practicability of making a railroad bed along that route serve the purposes of a levee.

The average height and width that would be required for such a purpose; the relative elevation of the Mississippi and the St. Francis river; the probable quantity of land that could be reclaimed in that way; its comparative fertility as well as its adaptability for purposes of cultivation when reclaimed; its comparative healthfulness, &c., &c. The committee have directed me to address you upon the subject, and any information relating to these matters that you may be pleased to furnish the committee will be thankfully received.

Very respectfully, your obedient servant,

B. F. LOAN,
Of Missouri, a Member of the Committee.

P. S.—It is very desirable that the committee should be furnished with copies of your latest maps compiled from your surveys.

APPENDIX I.

NEW ORLEANS, LOUISIANA,
July 1, 1868.

GENERAL: In compliance with the requirements of circular dated headquarters corps of engineers, June 10, 1868, I have the honor to submit the following annual report of progress, &c., in all works of river and harbor improvements and surveys in my charge since September 12, 1867, the date of my last annual report:

Survey of pass and Bayou Manchac and Amite river, Louisiana, with a view to determining the feasibility of establishing first-class steamboat navigation on their line between the Mississippi river and Lake Pontchartrain.

My full report of this survey, dated January 9, 1868, with projects, estimates, maps, and plans, was completed and transmitted early in January last, and is respectfully referred to for the information called for.

Survey of Galveston harbor, Texas, with a view of forming plans for its preservation and improvement.

This survey has been completed, and my full report thereof, dated June 9, 1868, already transmitted, with the documents, charts, and plans referred to therein, is respectfully referred to for the information called for.

Improvement of the mouth of the Mississippi river.

On the 13th of September, 1867, proposals for constructing and delivering the authorized dredge-boat, designed for executing the improvement, were opened. Only two proposals were presented, of which the following is an abstract:

DREDGE-BOAT FOR IMPROVING MOUTH OF MISSISSIPPI RIVER.

Abstract of proposals, September 13, 1867.

Name of bidder.	Occupation of bidder.	Gurantors.	Certifiers of gurantors.	Sureties.	Certifiers of sureties.	Amount.
Novelty Iron Works, Horatio Allen, president.	Builder of marine engines, &c.	Howard Potter, W. P. Trowbridge.	B. F. Weyrance, deputy collector.	Horatio Allen, W. P. Trowbridge,	.....	$338, 500
Thomas Stack	Ship builder.....	Arthur Leary, George Leary.	N. Clinch, deputy collector.	Arthur Leary, George Leary.	Geo. F. Betts, clerk of district court for southern district of New York.	275, 000

These bids were unacceptable, since they exceeded not only my careful and liberal estimate of the cost of building and delivering the vessel, but also the amount of funds available; and by headquarter's letter of September 16, 1867, I was directed to reject both, which I accordingly did.

By headquarters letter of the 19th September, 1867, I was authorized to advertise anew for proposals, with a more liberal arrangement of payments, and a greater publicity of the notice. The result fully vindicated the wisdom of this course. Five proposals were received, and were opened October 12, 1867. The following abstract exhibits them:

Abstract of proposals, October 12, 1867.

Names of bidders.	Occupation of bidder.	Guarantors.	Certifiers of guarantors.	Sureties.	Certifiers of sureties.	Amount.	Places of construction.	
							Hull.	Machine.
C. & R. Poillon.....	Ship-builder.....	Horatio Allen, N. L. McCready.	Geo. F. Betts, clerk U. S. district court.	Horatio Allen, N. L. McCready.	Geo. F. Betts, clerk U. S. district court.	$298, 000	Poillon's ship yard, New York.	Novelty Works, New York.
James Murphy & Co..	Steamship machinists.	A. W. Thompson, P. Poillon.	J. K. Stellwell, deputy collector of customs.	.....	.....	273, 000	New York.....	New York.
Thomas Stack.....	Ship-builder.....	Arthur Leary, Geo. Leary.	Geo. F. Betts, clerk U. S. district court.	Arthur Leary, Geo. Leary.	Geo. F. Betts, clerk U. S. district court.	267, 000	Brooklyn	Allaire Works, Fulton 300 New York.
Reaney, Son & Co....	Steamship machinists.	Wm. Stearns, D. P. Dieterick.	Chas. Gilpin, U. S. attorney.	.....	.....	237, 500	Chester, Pennsylvania.	Chester, Pennsylvania.
Atlantic Works, Oliver Edwards, president.	Steamship machinery.	Oliver Edwards, Mark Googins.	Thos. Russell, collector of customs.	Oliver Edwards, Mark Googins.	Geo. F. Betts, clerk U. S. district court.	233, 000	Boston.....	Boston.

Under authority contained in headquarters letter of October 14, 1867, I awarded the contract to the Atlantic Works of East Boston, Massachusetts, after fully satisfying myself as to the pecuniary responsibility of the proprietors and officers of that establishment, and of the sureties offered. The day following (15th) the contract and bond were executed The following is an abstract of the contract:

Articles of agreement, entered into this fifteenth day of October, eighteen hundred and sixty-seven, (1867,) between Brevet Brigadier General M. D. McAlester, major corps of engineers United States army, of the one part, and the Atlantic Works, Oliver Edwards, president, city of Boston, in the county of Suffolk, in the State of Massachusetts, of the other part.

This agreement witnesseth, that the said Brevet Brigadier General M. D. McAlester, major corps of engineers United States army, for and in behalf of the United States of America, and the said Atlantic Works, Oliver Edwards, president, for their heirs, executors, and administrators, have mutually agreed, and by these presents do mutually covenant and agree, to and with each other, in the manner following, namely: That the said Atlantic Works, Oliver Edwards, president, shall construct and equip ready for sea and for work, at Boston, Massachusetts, and deliver at such points as the engineer in charge may direct, in the Mississippi river, at or below New Orleans, a dredge-boat for improving the mouth of the Mississippi river, for the price of two hundred and twenty-three thousand dollars, ($223,000.)

* * * * * * *

That the said Atlantic Works, Oliver Edwards, president, shall commence work on the hull, engines, and machinery on or before the twentieth (20th) day of October, eighteen hundred and sixty-seven, (1867,) and complete the construction and equipment ready for sea and for work on or before the twentieth day of March, eighteen hundred and sixty-eight, (1868,) and complete the trials and trial trip and the delivery on or before the tenth (10th) day of April, eighteen hundred and sixty-eight, (1868.)

That payment shall be made, forty per centum of the contract price when the hull shall have been launched and approved, and the boilers and the cylinders of the three propeller engines shall have been completed and approved; thirty-five per centum of the contract price when the dredge-boat contracted for shall have been completed and approved, reserving twenty-five per centum of the contract price until the dredge-boat shall have been delivered and accepted.

On the 17th of October, 1867, I assigned First Lieutenant D. W. Payne, corps of engineers, as inspector of the dredge boat, with a view to securing a faithful performance of the contract, stationing him for the time at the place of construction, with full instructions for his guidance.

By headquarters letter of October 23, 1867, the contract was approved. The drawings and models were then placed in the hands of the contractors, and work was immeidately begun. At this juncture some unforeseen delay occurred on account of the difficulty of supplying working drawings as rapidly as required, the contractors having received the mistaken impression that the term "detailed drawings" used in the notice for proposals, and other preliminary information, included or implied also "working drawings." They, however, heartily united with me in extraordinary efforts to overcome the delay; and the progress made, and the character of the materials and workmanship which have been employed, are creditable to their energy, intelligence, and integrity.

By the 1st of January, 1868, the contractors had invested in the dredge-boat $65,237 49.

The following extract of Lieutenant Payne's weekly report of January 10, 1868, exhibits the condition and progress of the vessel on that date:

Up to date the work stands as follows: All the castings and forgings for the valve-gear are made, and about two-thirds of the work of fitting and finishing them done; all the injection, delivery, feed, check, safety-valves, and valves for the steam-chests are finished.

One cylinder has been bored and faced, another will probably be received in the shop this week; the piston-rods, upper heads for cylinders, bonnets for steam-chests, forward dead-wood pipe, and the stuffing-boxes for the propeller shafts and the cylinder turned. The crank shafts and the crank pins have been forged. The small air

pump has been boxed and faced; its bed is being planed. The lower cylinder-heads and the composition rings for the thrust bearings have been bored. The bush bearings, after dead-wood pipe, pistons and followers, have been cast. In general terms, about one-half of the work on the machinery is completed. There is some delay in obtaining the large castings; should the two remaining cylinders, the large air-pump, (castings received 11th,) and the large condenser, be brought to the shop within the next two weeks, I think the machinery will be finished in time. The boilers are about two-thirds finished; I think I can state safely that they will be completed by the 1st of March.

The hull is also about two-thirds finished. The lower-deck beams are in place; the ceiling is carried up as high as these beams; the beds for the engines and condensers are nearly completed, and 11 strakes of planking are on.

Mr. Smith assured me this morning that, in case we were favored with ordinary good weather, he would be able to launch the hull on the 10th of February.

So far all the work has been performed in the most satisfactory manner, and the contractors have evinced a desire to fulfill their contract honestly. I have made careful inspections nearly every day, and am able to say that the best of materials have been used, and the work has been performed in a workmanlike manner.

By the 29th January the contractors had invested $94,441 22 in the vessel.

On the 26th March an application for an extension of time in which to complete and deliver the vessel was made, by the following letter, indorsed by the inspector:

ATLANTIC WORKS, *Boston, March* 26, 1868.

SIR: We most respectfully solicit an extension of the time at which the dredge-boat was to be completed and delivered for two months. As you are aware, we were delayed for five or six weeks, for want of the drawings in detail, which were essential, and were to be furnished from New York.

We have found, also, unusual difficulty in obtaining through the foundery so many large castings. All are now in the machine-shop, save one condenser. This will unavoidably be delayed 10 days, in consequence of an accident to the mold during the late storm, the water penetrating to the pit in which it was placed.

We have used, we assure you, all possible effort to hasten forward the work, which we are confident has progressed with remarkable rapidity, considering the circumstances; and we will spare no exertion to complete and deliver the ship within the time, extended as above requested.

Yours, most respectfully,

FRANKLIN W. SMITH,
Treasurer.

Brigadier General M. D. MCALESTER,
23 *Rampart Street, New Orleans, La.*

ATLANTIC WORKS, *March* 27, 1868.

Respectfully forwarded to General M. D. McAlester, at New Orleans, with the statement that the contractors have made every effort to finish the dredge-boat by the time specified, but have been unavoidably detained, as herein stated.

D. W. PAYNE,
1st Lieutenant Corps of Engineers.

Having obtained from the sureties written acknowldgments, duly and legally subscribed, that their liabilities would in no way be changed by the granting of an extension, I took the following action on the application:

UNITED STATES ENGINEER OFFICE,
New Orleans, April 6, 1868.

SIR: I have received your letter of the 26th ultimo containing an application on behalf of the Atlantic Works for an extension of the time for the completion of the "construction and equipment ready for sea and for work," and the "trials and trial trip and delivery" of the dredge-boat now constructing by said Atlantic Works, for the improvement of the mouth of the Mississippi river, under contract with the United States.

The period of time for completing the construction and equipment of the dredge-boat ready for sea and for work is specified in the contract to be limited by the 20th day of March, 1868, and is hereby extended to the 30th day of April, 1868.

The period for completing the trials and trial trip, and the delivery of the said dredge-boat, is specified in the said contract to be limited by the 10th day of April, 1868, and is hereby extended to the 20th day of May, 1868.

The above extensions are the utmost that can be granted consistently with the public interests involved, and are believed to fully compensate for all delays on the part of the said Atlantic Works due to causes not foreseen at the signing of the contract.

Very respectfully, your obedient servant,

M. D. MCALESTER,
Bvt. Brigadier General, &c., in Charge of Mississippi river, &c.

Mr. FRANKLIN W. SMITH,
Treasurer Atlantic Works, Boston, Mass.

This action was duly reported and approved at headquarters.

On the 11th of April the vessel had reached that stage of progress which by the terms of the contract entitled the contractors to the first payment.

On the 27th of April Lieutenant Payne reported the probability of the trials and trial trip being delayed till the 15th of May. As this circumstance would delay the delivery of the vessel beyond the date contemplated, I called on Lieutenant Payne for a special report upon the efforts used by the contractors during the period included by the extension granted. He replied as follows, under date of May 16th, 1868:

Since the 20th of March the contractors have made every effort in their power to complete the boat at the earliest moment. All the workmen have been employed that could be used; more or less night work has been done since the middle of January, but during the last month their men have worked nearly every night. There is no especial cause for the delay—that is to say, they have not been very much detained by the weather, although it has been very bad; nor has there been but one accident. They underestimated the time required, and have undertaken more work than their facilities enabled to perform in the time specified. Should no accidents happen on the trial trip, and everything work satisfactorily, the vessel ought to leave here by the 26th instant.

The vessel was completed on the 28th of May, and a trial and trial trip were made on the 29th, the results of which are reported by Lieutenant Payne as follows:

ATLANTIC WORKS,
East Boston, Massachusetts, June 1, 1868.

GENERAL: I have the honor to report as follows upon the operations on board the Essayons during the week ending on the 30th of May, 1868:

On the 25th 30 tons of pig-iron were placed in the forward and after tanks; these tanks were then filled with water, the bulkheads carefully examined and the leaks marked. In pumping out the tanks the circulating pumps were revolved 300 times per minute, but delivered only about 300 gallons per minute. On the 26th commenced coaling; nine men were employed at this. By hoisting from both hatches of the schooner two gangs could have worked. The leaks in the bulkheads of the water tanks were calked. Painters were painting the engine-rooms. On 27th coaling and painting. All the coal, 380 tons, was on board by the evening of the 28th.

On the 29th all the engines were worked during the greater part of the day. No trouble was found with anything, except the circulating pumps. At 200 revolutions they did not throw sufficient water to permit the large engines to work faster than 30 revolutions. At this speed, with 30 pounds of steam, the vacuum in the after engine-room varied between 19 inches and 21 inches; in the forward room it averaged 15 inches. The forward propeller shaft warmed up a little in the thrust bearing, but was soon cooled off and gave no further trouble.

On the 30th at 9.30 a. m. the Essayons left the dock to proceed on the trial trip. The weather was very foggy, and the pilot not deeming it prudent to go outside, it was decided to run upon a mud bank to test the forward propeller and the scrapers. The vessel was drawing 13 feet 9 inches forward; the lowest point of the circle described by the extremities of the propeller blades was 15 feet 9 inches under water, and the bottom of the mud keel 16 feet 9 inches.

As the vessel approached and entered the bank the soundings were as follows, viz: 17 feet 6 inches, 17 feet, 16 feet 6 inches, 16 feet, 15 feet 6 inches, 15 feet, 14 feet 6 inches, 15 feet 6 inches, 14 feet 6 inches, 14 feet 6 inches, 14 feet, 14 feet, 13 feet 6 inches, 12 feet 6 inches, 12 feet 6 inches. The bottom was composed of soft mud, into which an ordinary sounding lead of eight pounds weight sunk about one foot when allowed to remain on it a few minutes. We approached the bank at a speed of about five miles per hour; after going about twice the length of the boat the propeller was three feet three inches in the mud, and the mud-keel four feet three inches. We worked here

about 10 minutes, the vessel moving ahead about two feet per second. The engines were making 30 revolutions at the start and kept up to 26 during the whole time we were working. She backed off and ran upon the bank again with the same results. The after scraper was then lowered in 17 feet water; boat was drawing 16 feet 4 inches aft. The hoisting gear was slackened so as to let the scraper into the mud as far as its weight would force it. When the scraper was lowered the vessel was moving forward at about four miles per hour, after-engines running; both engines were then started at full speed. The forward engine made 44 and the after 35 revolutions per minute. The scraper was dragged through the mud with great ease; boat moved at about six miles per hour. We then ran over a shoal about 100 yards wide, water 17 feet deep, with scraper down, with same result. The boom that supports the forward scraper was broken in the morning by the tug that took us out of the slip, so the forward scraper was not tested. Mr. Allen, president Novelty Works, was present, and expressed himself as highly pleased with the working of the engines. He agreed with me that the circulating pumps would not answer; said that Mr. Kinzie had made a mistake as to the size required, and that he would have larger ones sent on at once. When the scraper was tested the engines were run as rapidly as possible without heating the air-pumps and condensers.

When the new circulating pumps are put on board I propose to test both scrapers with the engines running at 60 revolutions. The thrust from both screws will amount to about 40,000 pounds. At 4.55 p. m. we ran out to sea about five miles beyond Boston light, when it began to get foggy, and, as the pilot thought it imprudent to go further, we returned to the city. In going out and back we ran about 25 miles; the log showed a speed of eight and a half knots when moving fastest. The engines average 39 revolutions; their speed varied with the vacuum obtained. In the forward engine room the vacuum varied from five inches to fifteen inches, but stood at 15 inches most of the time.

The temperature of the hot well varied from 140° to 180°. Vacuum gauge in after-engine-room varied from 14° to 15°, temperature of hot well from 100° to 120°. The boilers kept up 45 pounds of steam with doors open.

I am very highly pleased with the workings of the engines; all the journals kept cool and the cut-off worked well. The toes on the rock shafts need a little filing, in order that the valve-gear may work noiselessly. When the new pumps are on board, we will make another trip to sea. An indicator will be placed on the engines, and I can then give a more definite report regarding them.

I am satisfied with the test given the forward propeller that it possesses sufficient strength.

If you have any instructions to give me, with regard to the trial of the machinery, I would respectfully request to have them sent me by telegraph, as we will probably go out again in about 10 days.

Very respectfully, your obedient servant,

D. W. PAYNE,
First Lieutenant Engineers.

Brevet Brigadier M. D. McALESTER,
Engineer, New Orleans, Lousiana.

The failure of the circulating pumps (supplying cold water to the condenser and pumping out water tanks) was at first inexplicable; and their replacement, together with the various readjustments of valve-gear and other machinery, the necessity for which was developed in the trials, caused a further delay of two weeks. This delay cannot, I think, be fairly charged upon the contractors. The kind and size of pumps (Gerecke's patent turbinate rotary pump, 10-inch size) were embodied in the specifications. The following extract from Lieutenant Payne's report of June 8th seems to fix the blame upon the maker of the pumps:

From the 1st to the 6th of June the workmen were engaged in readjusting the valve-gearing of the engines and the pumps. The Novelty Works sent their chief draughtsman, Mr. Kinzie, to attend to the first, and the maker of the pumps was here to ascertain the cause of their inefficiency.

By the 4th the valve-gear of the engines was arranged and worked in the most satisfactory manner, but the pumps could not be made to work; the tubes of the condensers and the pipes leading to the pumps were examined to see if there was a stoppage anywhere; they were found to be perfectly clear; the pumps were then run at 280 revolutions, but did not perform any better. The maker of the pumps not being able to correct the difficulty, a set of 12-inch pumps were ordered and are to be here by the 10th. It seems that an alteration had been made in the pattern of the 10-inch pump, just previous to the making of those sent us, and it is supposed that the altera-

tion caused their inefficiency. There is no difficulty with the pump engines; they work admirably. Both scrapers have been strengthened by tension rods, as I informed you on the 4th. We are only detained from going to sea by the pumps.

On the 16th June the Essayons, all necessary alterations having been effected, her final trials had, and having been duly approved by the inspector, sailed for this city.

On the 21st, at a point 340 miles southeast of Cape Henry, the chief steam engineer reported that there remained machinery oil on hand for three days running only; and one of the eccentric yokes of the forward engines having been slightly bent so as to disable these engines, the course of the Essayons was changed for Cape Henry, arriving at Fort Monroe at 1.20 p. m. on the 24th. Colonel Baylor, of the ordnance department, very kindly offered the use of the ordnance shop, and repairs were at once proceeded with. The vessel sailed for this port from Fort Monroe yesterday, (June 30th,) at 8.30 a. m., and will probably arrive on the 4th instant, when she will be set to work as soon as practicable.

The following additional information relates to matters specially referred to in paragraphs 2 and 3 of the circular:

The following amount can be profitably expended upon the work during the present fiscal year:

For providing the second of the two dredge-boats authorized by Congress, joint resolution approved March 29, 1867....	$240,000
Working expenses and repairs.....	100,000
	340,000

The work is located in the collection district, and near the port of New Orleans.

For the last fiscal year the amount of revenue collected at the port of New Orleans is $4,403,459 23.

For the amount of commerce and navigation benefited by the prosecution of this work, see my annual reports of November 14, 1866, and September 12, 1867.

STATEMENT OF CASH.

Received during the fiscal year ending June 30, 1868	$215,000
Expended during the fiscal year ending June 30, 1868.....	239,000
Amount available, June 30, 1868.....	33,852
Amount required for year ending June 30, 1870	100,000

The nature of the work is such as not to admit of permanent completion. To maintain the contemplated channel depth of 20 feet in one of the passes, a perpetual annual expenditure of $100,000 is required, of which $75,000 is estimated for the working expenses of the dredge-boats, and $25,000 for repairs, buoys, &c.

Very respectfully, your obedient servant,

M. D. MCALESTER,
Brevet Brigadier General, Major of Engineers.

Brevet Major General A. A. HUMPHREYS,
Brigadier General and Chief of Engineers,
Washington, D. C.

I 1.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., March 3, 1868.

SIR: I herewith return the copy of bill H. R. No. 594, authorizing certain persons therein named "to take possession of the bar known as Pass à Loutre, at the entrance of the Mississippi, and to construct a canal without any expense to the government," and beg leave to submit the following remarks thereon:

Under the appropriation made for the improvement of the mouth of the Mississippi river, and the joint resolution authorizing the Secretary of War to build and operate two dredge-boats at the mouth of the Mississippi, a steamer is now building, under contract, to be finished ready for sea by the 20th March, and delivered in the Mississippi river on the 20th April, 1868, with suitable machinery expressly adapted to the deepening process. The plan adopted, which has been approved here, is the result of a very careful examination by Major and Brevet Brigadier General McAlester, corps of engineers, of all plans and means proposed for this purpose by various persons, including that of Messrs. McClintock & Scott, the grantees in the present bill. The steamer is of such character that any additional machinery found to be desirable may be added. By the use of this steamer and its appliances it is expected to obtain a depth of 20 feet at Pass à Loutre in from 30 to 40 working days, and eventually to obtain a depth of 24 feet, should such depth be desired.

The bar increases 300 feet in length on the seaward side every year, and whenever the normal or natural depth of any part of the bar is increased by machinery or other extraneous force, the river begins to deposit there and continues to deposit until the natural depth has been restored. For these reasons the work of deepening must be continuous, and to provide against injurious delays caused by accidents to machinery, and the necessity of docking occasionally for overhauling and general repairs, the construction of a second steamer is essential to the success of the plan. The second steamer, however, provides an excess of force for one channel, and by the addition of a third steamer operations can be carried on in the two chief passes at the same time, that is, in Pass à Loutre and in the Southwest pass. The cost of these three steamers would be $750,000, with an annual expenditure for working and repairs and maintaining buoys and other channel marks of $50,000 each. These steamers would continually maintain two channels at a depth of 20 feet, and it is believed that a greater depth can be secured with the same expenditures, that is, from 22 to 24 feet.

On the other hand, the grantees of the bill propose to open one channel but 17 feet deep.

Let us test the economy of the two schemes by considering each separately, and under the supposition that a choice is to be made between them.

The cost of General McAlester's project for one channel and for two channels of 20 feet depth has just been stated; that of the grantees will appear from the following estimate.

During the last fiscal year 3,953 vessels, (all of which are large,) with a tonnage of 2,290,461 tons, cleared from the port of New Orleans. (See last annual report from this office, printed page 363.) Allowing only one half this tonnage to use the channel of the grantees, we have (as each vessel cleared passes through the channel twice) 2,290,000 tons annually, upon which they are allowed to charge 50 cents per ton, or $1,145,000

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ecessity of docking occasionally for overhauling and general
e construction of a second steamer is essential to the success
ı. The second steamer, however, provides an excess of force
ınnel, and by the addition of a third steamer operations can
on in the two chief passes at the same time, that is, in Pass
nd in the Southwest pass. The cost of these three steamers
750,000, with an annual expenditure for working and repairs
ining buoys and other channel marks of $50,000 each. These
ould continually maintain two channels at a depth of 20 feet,
elieved that a greater depth can be secured with the same
es, that is, from 22 to 24 feet.

ther hand, the grantees of the bill propose to open one chan-
feet deep.

st the economy of the two schemes by considering each sep-
d under the supposition that a choice is to be made between

of General McAlester's project for one channel and for two
f 20 feet depth has just been stated; that of the grantees will
n the following estimate.

he last fiscal year 3,953 vessels, (all of which are large,) with a
2,290,461 tons, cleared from the port of New Orleans. (See
l report from this office, printed page 363.) Allowing only one
onnage to use the channel of the grantees, we have (as each
red passes through the channel twice) 2,290,000 tons annually,
ı they are allowed to charge 50 cents per ton, or $1,145,000

for the annual cost of one channel 17 feet deep. Besides the present moment does not appear to be a judicious one to introduce other operations than those of the officers of the United States.

The appropriation act of 1856, as well as that of 1866 and that of 1867, required that the deepening process should be carried on by contract. Now, however, by the joint resolution of March, 1867, the Secretary o War is authorized to build and operate two steamers for that purpose. If they fail to open a channel of suitable depth, then would seem to be the fitting time for the operations of Messrs. McClintock & Scott.

Pass à Loutre was selected by General McAlester for the commencement of the improvement of the mouth of the river from the following considerations:

The bar at the Southwest pass has a mean depth of 17½ feet, that at Pass à Loutre a mean depth of 15½. The least depth on the bar of the Southwest pass is 13 feet, on the bar of Pass à Loutre 11 feet.

The velocity of the current and the extent of tough clay patches are essentially the same for the two channels at the bars, while the extent of Pass à Loutre bar from 20 feet water outside to 20 feet water inside is materially less than that of the Southwest pass bar.

The à Loutre channel is less obstructed by wrecks, is less crooked, and its navigation less difficult than the Southwest pass channels; besides, as the pilot stations are at present located on the Southwest pass, it is almost exclusively used by commerce, and operations for improving the pass would meet with very material obstructions; so that the absence at Pass à Loutre of the crowd of vessels sometimes obstructing the Southwest pass constitutes an important consideration in its favor. Hence Pass à Loutre possesses decided advantages over the other pass for commencing the improvement.

The proposed bill excludes the officers of the United States as well as all other persons from doing any work upon Pass à Loutre at a time when it is believed that the means provided by the government will in a brief working period deepen that pass to 20 feet. If, however, the parties referred to in the proposed bill will undertake to open a canal or channel to the Gulf for vessels drawing 17 feet water through the South pass or the Southeast pass, instead of Pass à Loutre, their operations will not interfere with those going on under the engineer department, and that class of objections to granting the privilege they ask for will be obviated. The small shoal with 15 feet water in the South pass, about midway of its length, could be readily removed, and the same may be said of the shoal inside the bar of the Southeast pass. The bill in its present shape, however, I regard as one that would embarrass the operations of the United States.

Whatever disposition may be made of the proposed bill, I beg leave to recommend earnestly that the appropriation asked for the next fiscal year for the improvement of the mouth of the Mississippi may be granted.

Should the authority asked for by Messrs. McClintock & Scott be granted by Congress, I would suggest, as an essential modification of the bill proposed, that nothing in the bill shall be so construed as to exclude the officers of the United States at any time from any work or operations deemed necessary by them for deepening any or all the channels over the bars at the mouth of the Mississippi, and that the channel work of the grantees shall be restricted to the bar at the mouth of the pass that may be named in the bill as the one from which they shall cut or excavate a channel to the sea, and that they shall not be allowed to cut or open a channel through either bank of the pass. This restriction as to locality is necessary to prevent a mischievous diversion of water from

the passes which might, to one not familiar with the character of the river, offer an apparently easy but delusive way of opening a new channel.

I transmit herewith copies of General McAlester's three reports upon improving the channels at the mouth of the Mississippi, viz: of February 21, 1867, September 12, 1867, and of November 4, 1867.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Hon. E. M. STANTON,
Secretary af War.

I 2.

HEADQUARTERS CORPS OF ENGINEERS.
Washington, D. C., May 20, 1868.

DEAR SIR: Some exception was taken yesterday to the estimate made by me as to the amount of tonnage passing through the mouth of the Mississippi river, upon which toll would be collected by the parties proposing to open a channel there.

The foreign trade of New Orleans has been very much less since the close of the war than before, but we must expect it to return before long to its former magnitude, and the coastwise trade to increase.

By referring to the report of the Secretary of the Treasury upon commerce and navigation for the fiscal year ending June 30, 1859, we find that there cleared from New Orleans for foreign ports during that year 1,168 vessels, with a tonnage of 808,248 tons. The coastwise trade is not stated in the report, nor can I put my hand upon it readily, but by referring to the report of General McAlester, of November 15, 1866, upon the improvement of the mouth of the Mississippi, (page 241, Appendix X X to my report of January 26, 1867, upon river and harbor improvements,) we find that 1,561 American coastwise vessels entered the port of New Orleans through the mouth of the Mississippi during the fiscal year ending June 30, 1866, and that their tonnage was 892,459 tons. The tonnage from foreign ports was much less than in the years previous to the war. Using the tonnage from foreign ports previous to the war (1858–'59) we have tonnage from foreign ports entering the mouth of the Mississippi, 808,000; coastwise tonnage entering the mouth of the Mississippi, 892,000; total tonnage, 1,700,000.

The entrances and clearances being about equal, we have a total of 3,400,000 tons passing yearly through the mouth of the Mississippi river subject to tolls under the proposed bill, for all the vessels are large.

Now if a tonnage duty is to be paid by this commerce to provide for the maintenance of a deep channel, why should it not be paid to the United States rather than to private individuals?

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Hon. THOMAS D. ELLIOT,
U. S. House of Representatives, Washington, D. C.

I 3.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 25, 1868.

SIR: In compliance with the following resolution of the Senate of the United States of March 11, 1867, viz: "*Resolved*, That the Secretary of War be, and he is hereby, directed to detail an officer of the engineer corps of the army for the purpose of surveying Bayou Manchac, connecting with the Amite river, and leading into Lake Maurepas and Lake Pontchartrain, and report the cost of opening said streams with bayous to first-class steamboat navigation," referred to these headquarters "to detail an officer and for report," I beg leave to transmit herewith a copy of the report of Brevet Brigadier General M. D. McAlester, major of engineers, the officer charged with the survey, &c.

The views of General McAlester are concurred in. The maps referred to in the report will be transmitted as soon as they can be copied.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Hon. E. M. STANTON,
Secretary of War.

UNITED STATES ENGINEER OFFICE,
New Orleans, Louisiana, December 30, 1867.

GENERAL: By engineer department letter, dated Washington, March 12, 1867, I was ordered, in addition to my other duties, as soon as practicable, to cause a survey to be made of Bayou Manchac, connecting with the Amite river, and leading into Lake Maurepas, and Pass Manchac, connecting Maurepas and Lake Pontchartrain, and to submit a plan and estimate of the cost of opening said stream and bayous to first-class steamboat navigation; the project to include the opening of the head of Bayou Manchac, in the Mississippi river, and connecting the navigation of that river with the streams and lakes mentioned.

In pursuance of these orders, I assigned First Lieutenant I. K. Hezlep, corps of engineers, to the duty of conducting the field-work of the examination and survey about the 20th of April last, (he having returned from Fort Morgan on the completion of the operations under his superintendence at that place,) supplying him with the necessary instructions, verbal and written, for the purpose. Copies of his report and estimates, and accompanying maps, with profiles, sections, &c., marked A, are herewith submitted.

The completion and transmittal of this report has been delayed by the death of Lieutenant Hezlep, of yellow fever, which took place on the 13th of August last, and before the estimate could be fully completed, (as to the cost of the locks, flood-gates, &c.,) and by the subsequent suspension of all engineering operations under my charge in this vicinity, on account of the yellow fever epidemic.

Lieutenant Hezlep's report is respectfully referred to for a very full description of the features and peculiarities of the channels and waterways surveyed, their tributaries or branches, the country adjacent, and the soil to be dealt with. In connection with the difficulties and cost of establishing and maintaining the proposed continuous channel for navigation between the Mississippi river and Lake Pontchartrain, the

following considerations, resulting from the floods to which the Mississippi is annually subject, should also be borne in mind, viz:

1. The liability to extensive deposits in and in front of the river entrance of the proposed Bayou Manchac canal, incidental to a shifting of the river bed towards the west bank, necessitating proportional excavations as the floods gradually subside.

2. Incidental to the liability of the river to shift its bed towards its easterly bank, the tendency of the waters to cut away the river bank where the junction is made, undermining the flood-gates and locks, and converting the canal into a crevasse, flooding and damaging not only the canal and the proposed channel-way to Lake Maurepas, but the neighboring country and plantations.

3. The liability to crevasses in the Mississippi levees above and below the Bayou Manchac, causing the flooding of the proposed channel and canal, and of all the swamps and bottoms between the reverse slope of the river and Lake Maurepas.

The great crevasse of 1862, which occurred in the vicinity of Bayou Manchac, and between it and Baton Rouge, caused the water to rise in these swamps and bottoms to a line two and one-half miles from the river, and to a level 22 feet above the normal level of the water surface in the proposed channel and canal. (See map A for high-water line and mark of the crevasse.)

The second and third dangers are liable to be realized during the progress of excavations and constructions connected with the proposed Bayou Manchac canal navigation, to the injury of important parts of the work, and perhaps the total destruction of others. The power of Mississippi floods is too great to admit of control to the extent of obviating the first and second liabilities. The danger resulting from the third might be guarded against by means of levees on both sides of the proposed channel-way, extending from near Lake Maurepas to the vicinity of the Mississippi levee. These are not, however, included in the project and estimates. The expense entailed by any flooding of the excavations and constructions in the proposed canal during their progress, though they might be very great, are of so indefinite a character as not to admit of estimates.

The dimensions of the largest first-class steamboats now employed on the Mississippi are as follows: Great Republic, 330 feet long, 95 feet beam, six to seven feet draught, loaded; Richmond, 340 feet long, 86 feet beam, six to seven feet draught, loaded; but as boats of the peculiar construction adapted for river navigation cannot be trusted on Lake Pontchartrain, much less on the Mississippi sound, I have taken the steamboats of the "Morgan line," plying between this city and Mobile through Lake Pontchartrain, Mississippi sound, and Mobile bay, as specimens of "first-class steamboats," such as are alluded to in the order directing the survey, these being in every sense first-class steamboats, with side wheels, and so constructed as to navigate the Mississippi river, as well as the other waters named, with safety and efficiency. The largest of these is the "Mary," 235 feet long, 60 feet beam over all, (including the guards necessary for side wheels,) and six feet six inches draught for ordinary loads. Vessels drawing more than six feet six inches find difficulty in navigating the lakes and portions of the sound.

On this basis I have assumed the locks to have in the clear 250 feet length, 65 feet width, and the channel-way between the locks and Lake Pontchartrain to have a width at the bottom of 45 yards, the depth of water at extreme low water being seven feet, which width will permit boats to pass each other readily at low speed. The arrangement of

gates for locks so wide, sufficiently strong, and admitting at the same time of easy and rapid manipulation, will present considerable difficulty, but possibly the difficulty may be overcome by adopting gates of heavy construction and of great strength, moved by auxiliary machinery; otherwise the boats might be reduced in width to 30 feet or 35 feet by substituting screw propellers or stern wheels for side wheels; but with such modifications they could not be classed as "first-class steamboats."

PROJECT.

Proposed channel from Lake Pontchartrain to Bayou Crocodile.—The reverse slope of the bank of the Mississippi river at the locality of Bayou Manchac terminates at Bayou Crocodile, and the surface of the ground bordering the proposed channel from Lake Pontchartrain to the latter bayou is essentially level, admitting water throughout its extent, corresponding in level (during the absence of floods) with tide-water in the lakes. It is therefore proposed to make the excavations in this portion of the channel necessary to give it a depth, at lowest water, of at least seven feet, and a width of at least 45 yards, by means of floating dredging machines, similar to those used for excavating the numerous canals through the swamps intervening between the settled portions of the city of New Orleans and Lake Pontchartrain. Excavations will be necessary at the following named localities only: the bar at the Pontchartrain end of Pass Manchac, the bar at the Maurepas end of Pass Manchac, the bar at the mouth of Amite river, cut-offs and widenings of Amite river at 83 different points between its mouth and New river; the channel of Amite river, known as New river, (see map, where this channel is also marked as the locality of "Set. No. 2" of Lieutenant Hezlep's cross-sections,) and Bayou Manchac from its junction with Amite river to Bayou Crocodile, amounting to 2,518,897 cubic yards, as estimated by Lieutenant Hezlep. (See his report.)

Bayou Crocodile to Mississippi river.—That part of the proposed channel line comprised between Bayou Crocodile and the Mississippi river is marked by so much of old Bayou Manchac as lies upon the reverse slope of the Mississippi river bank. At low water on the bayou (during absence of floods in the Amite) depths of water varying between 0 and three feet six inches are found above the mouth of Bayou Crocodile, to a point 1,650 yards from it. Above this point the bayou is dry, except during seasons of floods in the Amite, (when the water backs up the bayou a mile or two further,) and crevasses in the Mississippi levees occurring in the vicinity. (During the crevasse of 1862 it contained three feet depth of water at its head just outside the levee.) The bayou is closed (and has been, according to the reports, since the time of General Jackson) by a dam in continuation of the levee. The bottom of the bayou at its head is 13 feet 6 inches above low-water mark in the Mississippi, and floods in the latter exceeding that height would send water through the former channel-way in the absence of the dam now closing it.

It is evident, therefore, that the conditions of the case are such (see, also, Lieutenant Hezlep's report) that the section of the proposed channel here in question must be in all respects a canal. And as there are no intermediate sources at higher levels whence water can be had for its service, the canal must have a single level, supplied at one end, corresponding to extreme low water, to serve for navigation at such stages of water. Furthermore, although lowest water level in the Mississippi river—as adopted in this report from observations hitherto—is two feet and three-quarters of an inch higher than extreme low water in the pro-

l channel-way, comprised between Bayou Crocodile and Lake Pont-
rain, (corresponding to low tide in the latter,) the difference between
vels is liable at some time in the future to diminish. At all events,
ow-water level in the river is variable, while that of tide-water is
tially constant. It will be judicious, therefore, to place the canal
at the level of low tide-water, as shown at Bayou Crocodile, estab-
ig the canal bed at a level (continuous between this point and the
) seven feet below the tide-level named. It should be noted that
rdinary tide oscillations felt in the lakes, averaging about four-
s of a foot, (see Humphrey's and Abbot's report, page 106,) are not
ptible at this point, being overcome by the wind and the long tor-
s channel intervening. Communicating directly with this level, a
is proposed to be placed in the main channel near the river. As
iver attains higher levels under the influence of floods, other locks
sponding to these levels must be brought into requisition. These
ional locks it is proposed to place in auxiliary side canals commu-
ing with the main canal at a point between the lowest lock of the
(the one first named) and the river. The total excavation for these
ls, main and auxiliary, is estimated at 6,840,732 cubic yards.

cks.—The maximum oscillations of the Mississippi at Baton Rouge
Donaldsonville are respectively found by adding 0.5 foot (see table,
170, Humphrey's and Abbot's report) to 34.3 feet, and 27 feet, (see
, page 109, Humphrey's and Abbott's report,) and amount to 34.8
7.5 feet respectively. Interpolating on the supposition that the sur-
planes of the river have a uniform slope between these two points,
naximum oscillation at the head of Bayou Manchac is found to be
feet. Correcting this result by information obtained from intelli-
persons residing in the immediate vicinity, I have assumed, for the
oses of this report, 32 feet as the amount of the oscillation at the
r point. Adding two feet for difference of level between low water
e river and the canal, there results 34 feet for the total lift between
vater in the canal and high water in the river. This lift it is pro-
l to overcome by four locks of nine feet lift each, thus allowing a
in of two feet for floods higher than hitherto recorded. The lowest
or lock No. 1, is to be placed in the main canal as above stated. In
that the navigation may remain uninterrupted during all stages
e river, the other three locks are to be placed in three branching
canals, as illustrated by Fig. 3, (see map.) Lock No. 1 would alone
ed for all stages of the river not more than nine feet above tide-
r. The river rising more than nine feet above tide-water, flood-gate
(see Fig. 3) is to be introduced, and lock No. 2 brought into use in
ection with lock No. 1. When the flood reaches a height of 18 feet
more, (referred to tide-water,) flood-gate No. 2 is to be placed in
ion, and lock No. 3 used in connection with locks Nos. 1 and 2. For
its exceeding 27 feet, flood-gate No. 3 is to be used, and all four of
ocks. Fig. 3 fully illustrates the plan proposed, and the use of the
and flood-gates for all stages of water. The still water backing
the bayou and canal from floods in the Amite will not interfere
the working of the lock and flood-gate system.

e interior horizontal dimensions of the locks will be, as before
d, as follows: 250 feet long, 65 feet wide; their interior depth will
feet; their upper and lower gates will be 18 feet high. It is pro-
l for obvious reasons to construct the locks of timber, founding
upon areas of piles driven about six feet apart, measured in lines
lel and perpendicular to the axis of the locks.

is proposed to construct the locks essentially like the "Vallette
ng dock," (a description of which, by Lieutenant D. W. Payne,

corps of engineers, is appended,) since the strains to be resisted are essentially the same in the two cases. The principal modifications would consist in dispensing with the sides, ends, and backheads appertaining to the dock's hold, bringing the bottom of the hold up in contact with the deck of the dock, increasing the strength of all the stanchions employed in the sides, and introducing diagonal braces.

It is estimated that each lock foundation (including the usual accessories) will require 13,000 piles, each from 20 to 35 feet in length; and that the superstructure (including the capping of the piles) will require 3,975,200 feet of timber, board measure.

Flood-gates.—Owing to the loose and treacherous character of the soil and substrata to be dealt with, the establishment of flood-gates of adequate strength and stability will be an engineering problem of the greatest difficulty. Three flood-gates at least will be required, each 65 feet wide. Flood-gate No. 1 is to be 45 feet high, (reaching four feet above high water,) and must be able to sustain a head of water of 25 feet, (deducting nine feet, the lift of lock No. 1, from 34 feet, the total maximum lift.) Gate No. 2 must have a height of 34 feet, and sustain a head of water of 16 feet. Flood-gate No. 3 will be 25 feet high, and must resist a head of seven feet.

Whatever the character of gates adopted, the abutments and foundations supporting them should be of the most substantial character; and as the treacherous nature of the substrata renders the use of heavy masonry hazardous and enormously costly, it is proposed to employ timber alone (swamp cypress) for this purpose, with piles for foundations.

It is proposed to form flood-gate No. 3, and the lower section of each of the others, by means of a caisson, similar and similarly manipulated to the one used for closing the entrance of the Brooklyn navy yard dry dock, the vertical sections of which are rectangular, and the horizontal ones two equal curves joining at their ends with their convexities outwards; the caisson to be 25 feet high, so that when sunk into position the top shall be seven feet higher than the top of the corresponding lock. The remaining 18 or 20 feet of gate No. 1, and 9 or 11 feet of gate No. 2, it is proposed to form by means of several open-built beams, having an outline corresponding to the horizontal section of the caissons superposed flatwise on the latter and on one another—the caissons to be floated and sunk into position, where they will rest on the foundation at the bottom of the canal and against the abutments. The beams to be superposed as the river rises by means of derricks or cranes established on top of the abutments, and placed also with their ends resting against the abutments, where the pressure of the water will retain them, their flotation being neutralized by adequate weights placed on the uppermost one. The average number of piles estimated for the flood-gates is 300 each.

Estimate.

SURVEY.

For finally locating and laying out the entire work.....	$10,000 00

CLEARING GROUNDS READY FOR WORK.

For felling trees on space occupied by the channel, and on space 20 yards wide, on either side, 900 acres, at $5 per acre.....	4,500 00
Clearing drift-wood out of Bayou Manchac, 8 miles, at $200 per mile.....	1,600 00

EXCAVATIONS.

Bars in Lake Pontchartrain and Maurepas, Amite river, and Bayou Manchac, between Lake Maurepas and Bayou Crocodile, 2,518,897 cubic yards, at 25 cents per yard	$629,724 25
Canal and side canals between Bayou Crocodile and Mississippi river, 6,840,732 cubic yards, at 30 cents per yard	2,052,219 60

LOCKS.

For each lock 13,000 piles purchased, prepared, driven, and trimmed ready for the reception of the timber of the superstructure, are estimated to cost $7 each, amounting to	91,000 00
For the superstructure, (including capping of piles and gates,) 3,975,200 feet, board measure, of timber, purchased, delivered, framed, and built into the lock, (including all carpenter and joiner work,) is estimated to cost 4 cents per foot, amounting to	159,008 00
4 locks, at $250,008 each	1,000,032 00

FLOOD-GATES.

For 3 flood-gates, 900 piles, driven and completed, at $7 each, ($6,300;) 21,600 feet, board measure, of sheet piling, (plank 12 feet long and 4 inches thick,) at 4 cents per foot, ($864;) 3 caissons containing 175,500 feet, board measure, of timber, carpenter, joiner, calker, iron, and painter's work, included, at 4½ cents per foot, ($7,897 50;) grillage complete, 260,000 feet, board measure, of timber, at 4 cents per foot, ($10,400;) 6 abutments complete—2 of them 45 feet high, 2 of them 36 feet high, and 2 of them 27 feet high—total height of 216 feet, containing 1,101,600 feet, board measure, (facing, backing, and ties,) at 4 cents per foot ($44,064,) and open-built beams complete, forming the portions of flood-gates Nos. 1 and 2, superposed on the caissons for the total height of 31 feet, 63,180 feet, board measure, at 4½ cents per foot, ($2,843;) aggregate cost ready for use	72,368 60

AUXILIARY MACHINERY.

Machinery for manipulating and handling lock-gates and flood-gates, estimated	30,000 00
Grand aggregate	3,800,444 45

The above estimates are very close, and are more likely to prove too small than too great, especially those relating to the excavations. The very lowest rates at which ordinary levee embankments can now be made in this vicinity is 33 cents per yard, although the embankments and corresponding excavations whence the earth is taken are in very near proximity, and the soil to be dealt with quite dry. Much of the proposed canal excavation will require the earth to be elevated through considera-

ble heights, and transported over considerable distance; and much difficulty will arise from the presence of water in the lower portions of the excavation.

Of all the channel ways forming connection or partial connection between the Mississippi river and the lakes and sound, the one proposed is least favorable, in all respects, for extension and improvement as proposed. On account of the greater oscillations of the Mississippi river, and the greater width of the reverse slope of the river bank at the point of junction, and the greater length to be improved, the cost, both of its improvement and preservation, will be vastly greater than many other and much preferable lines that are available; and the liability to accidents leading to interruptions of navigation, and even the destruction of the work, far more imminent. The channel proposed, when completed ready for navigation, will be less useful and convenient than many others that might be selected, since it will present about 75 miles of intricate navigation between the river and Lake Pontchartrain, which cannot be accomplished at a speed exceeding five miles per hour, the whole time required for the passage, including locking, being about 16 hours.

A canal connecting the lake directly with the river, at almost any point between Bonnet Carré bend and the city of New Orleans, would, in all respects, be preferable. (See map marked B.) At several such points the canal would not exceed six miles in length, and for more than half this length the depth of the excavation would not exceed nine feet.

Were it a question of merely connecting the river with Mississippi sound, and its branches and inlets, a canal connecting the river with Lake Borgne, between the Chalmette line of fortifications and English Turn, (see map B,) would be still more advantageous and feasible in all respects. There are at least two bayous heading within three miles of the river, and affording 7 to 16 feet of water thence to Lake Borgne, which latter affords 8 to 10 feet of water from the bars at the bayou mouths to the sound.

As an example of these several preferable connections, I caused to be made a survey of the line connecting the river, at a point about midway between Carrollton and Camp Parapet, with "the new canal," at a point near Metairie ridge, (Bayou Metairie, see map marked C,) with estimates of the cost of completing the entire connection between the river and the lake, according to the requirements specified, viz: width, 45 yards; depth of water, seven feet, and suitable locks and flood-gates.

The difference of level between high water in the river and low tide in the lake is about 17 feet, (see Humphreys's and Abbot's Report, pp. 109, 113, and 170,) and but two locks and one flood-gate will, therefore, be required.

Estimate.

SURVEY.

Laying out and marking the work.....	$3,000 00

CLEARING GROUND.

Clearing trees from 30 acres of ground, at $5 per acre.....	150 00

EXCAVATION.

1,030,344 cubic yards of excavation, at 25 cents per yard...	257,586 00

LOCKS.

Two locks complete, at $250,008 each	$500,016 00

FLOOD-GATES.

For one flood-gate complete, including foundation, abutments, and the caisson	19,187 16

AUXILIARY MACHINERY.

Machinery for manipulating locks, gates, and flood-gates, estimated	6,000 00
Total	785,939 16

The "new canal" is at present about 60 feet wide, and has six feet of water, and terminates at the "new basin," a little less than one mile from the river. It is owned by the State of Louisiana, (having lately reverted to it,) and is leased to private parties for a term of years, one of the terms of the lease requiring that the lessees widen and deepen the canal. Some progress has been made in widening it to 100 feet, and deepening it to about nine feet. To remove the cypress stumps requires the excavation to be nine feet deep in the first instance. After the removal of these, which is usually done with Osgood's excavator, there is no difficulty in obtaining, say, 16 feet depth with the same machine. All similar excavations in the swamps bordering the lakes, and the low ground bordering the river, are made by this machine.

It is set up on a scow which floats in the water, with which the excavations fill as fast as they are made.

Supposing the proposed connection to be made at any point below Bonnet Carré bend, the locks and flood-gates could be entirely dispensed with by terminating the canal at a point, say, 45 yards from the crest of the levee or river bank, and providing facilities, say, cranes or platforms on wheels, worked by steam, for transferring freights rapidly between boats in the two waters. By this arrangement any boats or vessels now on the river and the shallow tide-water of the lakes and sound, or which may be hereafter introduced, could be brought to the point of transfer and exchange cargoes.

The great cost and risk attending any device for connecting the waters of the Mississippi river continuously with those of the lakes would also, by this arrangement, be avoided.

Very respectfully, your obedient servant,

M. D. MCALESTER,
Brevet Brigadier General, Major of Engineers.

Brevet Major General A. A. HUMPHREYS,
Brigadier General and Chief of Engineers, Washington, D. C.

NEW ORLEANS, *Louisiana, July* 31, 1867.

SIR: In compliance with your letters of instructions dated New Orleans, Louisiana, April 22 and 29 and May 8, I have the honor to report that I proceeded with a surveying party to Bayou Manchac on the 24th day of April, and made an examination and survey of that bayou, the

Amite river, and of the bars at the mouth of the Amite river, and at the east and west ends of Pass Manchac.

The object of the survey being to ascertain as near as practicable the amount of excavation necessary in order to render the streams mentioned navigable for steamers of the first class, (those of the Morgan line between this city and Mobile being taken as a standard,) it was assumed that the channel should be at least 45 yards wide at the bottom, with a depth of seven feet, the banks having a slope of one on one, and the calculations which follow are based upon this assumption.

Cross-sections of the bayou were taken every fifty yards; the "0" of vertical measurement being taken at low water at the section, unless the channel is dry at low water; horizontal measurements in yards, vertical in feet.

The sections were arranged in five sets, each set of sections being continuous. Set No. 1 extending from the Mississippi river to the Amite river; set No. 2 covering that portion of the Amite known as New river; set No. 3 the bar at the mouth of the Amite river; sets Nos. 4 and 5 the bars at the west and east ends of Pass Manchac, respectively. The sets and sections were numbered from the Mississippi eastwardly.

The work progressed favorably and was finished on the 20th of May, 1867. The water being high and the current rapid in the Amite river, in consequence of the spring flood, some of the measurements given relating to that river are necessarily inaccurate, but the errors are small and it is thought compensating.

The bayou for a distance of eight miles from the Mississippi river (to Bayou Crocodile) is filled with logs, growing trees, and undergrowth, and is dry at low water to within a mile of this point. To the Crocodile it has an average width of about 20 yards; from this point to Ward's creek it has an average width of 30 yards, but it is obstructed by falling and leaning trees, logs, &c. From Ward's creek to the Amite it has been cleaned out and is navigated by a small steamer, there being a depth of seven feet nearly all the way up at low water.

At low water the current in the Manchac is dependent entirely upon the winds, high easterly winds backing the water up the Amite causing it to flow up the Manchac.

The Manchac has three tributaries, which carry into it the drainage of a large portion of the country extending from Baton Rouge above down to New river landing below. Of these the Crocodile is the most important, being the outlet of Spanish lake which receives all the drainage from Bayous Brand and Paul. It is at high water about 25 yards wide at the water surface; at low water it is dry for part of its length. The next inlet below is Bayou Fountain, which drains a large portion of the high land and of the land between Baton Rouge and the head of the Manchac. Along the river Ward's creek is the least stream of any importance which flows into the Manchac, and it at low water discharges but little water. None of these tributaries are high enough to supply reservoirs to feed the canal proposed.

At the junction of the Manchac with the Amite river a bar has formed some 20 yards wide and extending down the river for 50 yards. There are but three feet of water on this bar when the river is at its lowest stage. From this point down to what is known as New river, and from New river to Lake Maurepas, the Amite river is generally over 45 yards wide and from 12 to 25 feet deep at low water. New river is of an average width of 38 yards, and is very crooked and deep.

The bayou Manchac and Amite river are bordered throughout their whole length by heavy forests, with the exception of a few plantations

and landings. In many places the trees overhang the bank both of the river and the bayou so as to render navigation difficult and dangerous even for small steamboats. In the highlands are found pine, ash, and oak; in the swamps, cypress, gum, white oak, &c.

The soil along the Manchac is a stiff clay, growing firmer as you leave the Mississippi river, the coarser materials being deposited near the Mississippi bank. The banks of the Manchac have a reverse slope similar to that of the Mississippi, there being, however, a greater fall in the same distance. Along the Mississippi the average reverse slope of the natural bank is about seven feet in the first mile, while along the bayou the average reverse slope is about three feet in the first hundred yards. At the mouth of the Manchac the soil becomes mixed with sand, but the proportion is small and does not in any way obstruct the channel by forming bars; and, in fact, at the points where shallow water could be expected, the banks are in places from 12 to 15 feet high, and stand almost perpendicular.

The high water of the spring backs up the Manchac so as to give in many places below Bayou Crocodile a depth of 20 feet and over, overflowing a large portion of the country on the south side; and falling rapidly a very rapid current is formed, rendering navigation extremely difficult.

The slope back from the Mississippi along the Manchac is most rapid for the first two miles, when it becomes more gradual. In order to make the estimate of the excavation more accurate, avoiding the error of assuming the slope from the Mississippi to the Crocodile as uniform, a line of levels was run from the head of the Manchac to its junction with the Crocodile, and the following results obtained:

Difference of level of natural bank of Mississippi in first two miles and a half is eight feet five inches; between this point and the Crocodile, (where the direction of current at low water is dependent entirely upon the direction of the wind and the rise and fall of the Amite,) eleven feet three inches; making a total of 19 feet eight inches.

Difference of level between extreme high water in Mississippi of 1862 and extreme low water in the bayou at the Crocodile, 34 feet and three-fourths of an inch. The extreme fall of the Mississippi river being 32 feet nearly, this gives the difference of level between low water in the Mississippi and in the Manchac at two feet and three-fourths of an inch.

As there is no body of water near the Manchac which can be used as a reservoir to supply locks for different levels in the canal, it must be excavated down low enough to give the required draught of seven feet at low water, which places the bottom of the canal, nine feet below the low-water line of the Mississippi river, or 37 feet seven inches below the natural bank of the Mississippi, at the crest of the channel bank.

To overcome this rise, at least four locks will be required, placed in four different side canals, a project for which is appended:

Amount of excavation required and the estimate of the cost of the same.

*From Mississippi river to Bayou Crocodile, 6,295,394 cubic yards, at 30 cents per yard	$1,888,618 20
Side canals for locks, 545,338 cubic yards, at 30 cents per yard	163,601 40
*From Bayou Crocodile to Amite river, 1,903,520 cubic yards, at 25 cents per yard	475,880 00

* In all cases where the canal follows the existing natural channel-way the curvature of the latter is deducted in estimating the excavation for the canal.

New river, 96,783 cubic yards, at 25 cents per yard....	$24,195 75
Points of Amite river 464,000 cubic yards, at 25 cents per yard.....	116,000 00
Bar at mouth of Amite, 9,668 cubic yards, at 25 cents per yard.....	2,417 00
Bar at west end of Pass Manchac, 24,077 cubic yards, at 25 cents per yard.....	6,019 25
Bar at east end of Pass Manchac 20,849 cubic yards, at 25 cents per yard.....	5,212 25
	2,681,943 85

Timber and lumber for one lock.

Thirteen thousand piles, 20 feet to 35 feet long, one foot in diameter; 3,125,200 feet of 12-inch by 12-inch timber, board measure; 600,000 3-inch plank for sheeting and gates; 250,000 feet, 12-inch by 12-inch timber, gates.

The cost of a project for opening a canal from near Camp Parapet, on the Mississippi river, just above Carrollton, to the point near the Metairie ridge, where the new canal crosses it, and of widening and deepening "the new canal" from that point to Lake Pontchartrain, is as follows:

	Cubic yards.
For canal 300 yards long, 17 feet 1 inch deep and 24 yards wide, for locks at low water.....	50,820
For canal 200 yards long, 9 feet 4 inches deep and 24 yards wide, for lock at high water.....	16,874
For canal from Camp Parapet to foot of slope, 1½ miles, 45 yards wide and from 17 feet 1 inch to 8 feet 6 inches deep.	560,340
For canal from foot of slope to new canal at Metairie ridge, 45 yards by 8 feet 6 inches, and widening and deepening new canal thence to lake Pontchartrain	402,310
	1,030,344
1,030,344 cubic yards of excavation, at 25 cents per yard...	$257,586

In opening either of these canals an item of some importance must be considered, the deposit in the lakes of the sediment from the Mississippi river. This will be constantly going on, and will be accompanied with considerable expense.

Very respectfully, your obedient servant,

J. K. HEZLEP,
First Lieutenant Corps of Engineers.

Brevet Brig. Gen. M. D. MCALESTER,
Major of Engineers.

NEW ORLEANS, LOUISIANA,
June 18, 1867.

SIR: I submit herewith a description of the Valette floating dock at Algiers, the largest one in the river. Dimensions: length of hold, 260 feet; length of outriggers, 50 feet; depth of hold, 10 feet; breadth of

dock at deck within sides, 83 feet; same at top 91 feet 5 inches; width of sides between sheathing, 5 feet. Draught of ship can take 18 feet.

The bottom of the hull is composed of outer planking three inches thick; floor timber 12 by 12 inches, two feet apart, placed athwart ships; timbers 12 by 12 inches in juxtaposition bolted through and through, running fore and aft; timbers 12 by 12 inches, 3 feet apart athwart ships, and inner planking 3 inches thick. The deck is composed of timbers 12 by 12 inches, 2 feet apart athwart ships, and 3 inches deck plank. The sides of the hold are composed of upright stanchions 12 by 12 inches, two feet apart, and planking three inches thick. The hold is divided along its axis by a bulkhead 42 inches thich; on either side of this, and parallel to it, are two others one foot thick. There are seven bulkheads one foot thick running athwart ships.

The hold is thus divided into 48 water-tight compartments, from which pipes lead to the pumping wells.

The outer sheathing of the sides of the dock is three inches thick, and the stanchions 5 by 10 inches, and from two to three feet apart; the inner sheathing is three inches thick, and the stanchions are five to eight inches, and from two to three feet apart.

There are two outer and two inner clamps, six inches by two feet on each side. In each side there are eight water-tight compartments and four pumping wells.

There is such an arrangement of valves that any one of these compartments can be filled or emptied separately. There are four discharging and four receiving valves on each side. Two engines of two feet stroke and 11-inch bores, and 16 pumps, 20 by 20 inches, are employed in pumping out the dock.

The capacity of the pumps is such as to raise a vessel drawing 14 feet of water in forty minutes. I was unable to ascertain the speed at which the engines are usually run, so as to determine the amount of water discharged per second.

The same length of time is required to sink as to raise the dock.

About 1,080 pounds of coal are used in raising a vessel drawing 14 feet.

The capacity of the dock is about 2,500 tons, and it costs $168,000.

Very respectfully, your obedient servant,

I. W. PAYNE,
First Lieutenant Engineers.

Brevet Brig. Gen. M. D. MCALESTER,
Major of Engineers.

Sent to headquarters engineers with letter of January 10, 1868, and three maps marked A, B, C.

M. D. MCALESTER,
Brevet Brig. Gen. Major of Engineers.

I 4.

UNITED STATES ENGINEER OFFICE,
New Orleans, June 9, 1868.

GENERAL: The examination and survey of Galveston harbor having been completed, I have the honor to report incidents, results, projects and estimates relating thereto, as follows.

Work was begun under instructions communicated to me in the following letter:

ENGINEER DEPARTMENT,
Washington, March 22, 1867.

GENERAL: A recent examination of the harbor of Galveston, Texas, by the coast survey, has developed changes in that harbor of a character so serious as to threaten its existence even, if allowed to continue, and it seems highly important that steps be at once taken to ascertain whether and how the accumulations of obstructions can be stopped, and the bar deepened so as to meet the demands of commerce.

On the inner bar, which is the part occasioning the greatest present inconvenience, and to which the improvements are most needed, there was, in 1851, when the coast survey thoroughly surveyed the harbor, a depth of thirteen feet at the shallowest point, which depth has diminished rapidly in the last two years, and is now found to be only nine and one-half feet, which is nearly three feet less than on the outer bar.

Hitherto this harbor has been the best on our whole coast from the Mississippi to the Rio Grande, and is the one from which is exported a large proportion of the productions of the State of Texas. It is therefore of the highest importance to the commercial interests of the nation that the capacity of this harbor should be maintained if possible.

The recent survey has developed the further fact that Pelican spit, upon which it has always been proposed to locate the fortifications for the defense of this harbor, and when, just before the war, preparations were made for the commencement of a fort, is subject to considerable changes, which would render any construction upon it unadvisable till the character of those changes has been more fully investigated.

Before any intelligent plan for improvement can be devised, it will be necessary to have more detailed information in regard to the changes that have taken place than are furnished by the late examination by the coast survey above referred to, and also a full knowledge of the direction and strength of the currents, the effects of waves and storms, character of the bottom at various points, whether sand, mud, &c.; also the character of the underlying strata to as great a depth as practicable.

You will take measures to collect all the information above indicated, with the view of preparing plans and estimates of the most practicable and effective mode of improving the harbor, and of erecting suitable breakwaters for its protection.

The expenses of the examination and survey will be paid from the appropriation for examinations and surveys on the Atlantic coast. You are requested to present an estimate of the cost of the survey as soon as practicable.

A copy of the act of Congress directing the survey, &c., is herewith transmitted.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General and Chief of Engineers, Major General of Volunteers.

Brevet Brigadier General M. D. MCALESTER,
Major of Engineers, New Orleans, La.

Considerable delay occurred in efforts to obtain experts competent to perform the work. After applying unsuccessfully in this vicinity, and to the several officers of engineers stationed in the eastern, northern and western States—there being at the time a great demand for expert surveyors and hydrographers for the extensive works of river and harbor improvement, and railroad and other civil constructions in those regions—Mr. J. E. Hilgard, assistant in charge of the Coast Survey office, for the superintendent, on application from headquarters corps of engineers, very kindly ordered the coast survey party already at work in the harbor to report to me for duty, at the same time placing at my disposal the results which the party had already accumulated during the current working season. I received notice of this about the 10th of May, 1867, and on the 15th following ordered Lieutenant Stanton, corps of engineers, one of my assistants, to Galveston, in immediate charge of the work, with full instructions. The coast survey party, being at San Luis Pass, did not arrive and report to Lieutenant Stanton till the 31st of May. Work was commenced on the 4th of June.

Receiving notice from the Coast Survey office that it was customary to relieve its parties on the coast on the 15th of July, I, under instructions contained in headquarters letter of June 19, 1867, directed work to be suspended on that date; but the party becoming previously thereto crip-

by sickness, and the yellow fever becoming epidemic in the vicinity, ıtions had to be suspended on the 8th of July.
e yellow fever raging about Galveston bay till the 1st of December wing, and the coast survey party consequently not reporting in this till about the 1st of January, operations in the field could not be ned till about the 8th of January, 1868, after an unavoidable suspen- of six months. The field-work of the examination and survey was pleted on the 9th of April, 1868, having been very much retarded unusually stormy weather.
consequence of the caution contained in headquarters letter of Jan- 20, 1868, that "the appropriation for examinations and surveys for Atlantic coast was almost exhausted, and that there was no other opriation applicable to the object," together with a desire to submit report before the adjournment of the present session of Congress, cope of the field-work has since that date been somewhat curtailed from riginal project, in respect to current observations and borings. The ipal omissions are the borings on the site of the dam suggested s San Luis Pass. It may, however, be taken for granted that the ıcters of the bottom and substrata at this locality are essentially same as at the points in Galveston bay where borings were made. current observations, although not exhaustive for the entire water connected with the inner channel and bar, comprise those which ıecessary to determine the characters of the currents which have lirect effect upon their depth of water.
e facts and conclusions arrived at by the examination and survey, estimates of cost of various projects for the improvement and pres- ion of the inner harbor and its entrance, are very fully presented ıe report of Lieutenant Stanton, hereto appended, and the charts ed A, B, C, D, E, F, G, and H, herewith transmitted.
ree projects for accomplishing the desired objects present them- s:
st, that of increasing the amount and velocity of the water flow- through Galveston channel, (across the inner bar,) by deflecting ıgh it a portion of that which now, flowing in and out through ar channel, fills and empties the reservoir formed by Galveston ınd East bay, by means of a system of jetties resting on Pelican d and spit and intersecting Bolivar channel, thus deepening and pre- ng the channel by increasing the abrading effort of the current.
ıd, that of directly increasing the area of the reservoir which fills empties through Galveston channel, thus increasing the abrading of the current by that portion of West bay which is to the west- of Karonkaway Point, by means of a dam closing San Luis Pass.
l, that of excavating and preserving the required channel by means achinery.

ct of a system of jetties intersecting Bolivar channel from the shoals of Pelican island and spit.

r positions, descriptions, and detailed estimates of the cost of these s, reference is respectfully made to chart "E" and Lieutenant on's report. The aggregate cost of the system is estimated at 0,000.
e kind of construction adopted for the purpose of estimates is the economical, consistent with any assurance of stability, practicable e Texas coast, there being no stone quarries in or near the Gulf s. The concrete blocks are proposed to be laid without mortar in

courses, and to be lowered into position through the water (which is clear) by means of cranes, the blocks in consecutive courses breaking joints. To diminish the difficulty of placing the blocks, the vertical joints may be as wide as six inches. The first course is proposed to be placed on the surface of the bottom or shoal. The piles are designed to serve as guides in laying the concrete blocks, and, in the absence of mortar in the joints, to retain them in position while settlement is going on, and against the disturbing efforts of storms. The width of jetty is generally taken to be 50 per cent. greater than the corresponding height; but when the basis is mud, (which may be the case for small portions of the Pelican Island jetty,) the lowest course is proposed to be extended beyond the lines of piles, and its edges connected with the top of the structure by offsets, thus increasing the base in order to obviate too great settlement. The jetty-heads are made large enough to receive light-houses if necessary.

The upper or Pelican Island jetty is designed to cut and deflect to the westward of the island, and through the Galveston channel, the entire ebb current of the branch of Bolivar channel which is between the series of parallel shoals to the northeastward. At first thought, this effect would seem to result inevitably and permanently from the introduction of the jetty, the line A B (chart F) separating the two reservoirs, being shifted to the eastward so that its extremity "A" should rest at the jetty head, while its intersection with the west shore of the bay moved northward, thus indirectly increasing the area of the reservoir emptied through Galveston channel.

The Pelican Spit jetty is designed to deflect a portion of the flood current now entering through Bolivar channel, and cause it to pass through Galveston channel. Incidentally it would undoubtedly arrest the westerly movements of the spit and of the mouth of Galveston channel, which have hitherto been in progress, and render the spit secure for fortification and other purposes. This jetty as proposed, however, intersects but a very small portion of the Bolivar channel, it being deemed unsafe to carry it beyound the 12-foot curve, on account of the rapid declivity of the shoal in that direction and the great exposure to heavy seas coming in from the Gulf. Even terminating at the 12-foot curve, it might be necessary to use extraordinary precautions to prevent the undermining of the jetty-head.

These two jetties, constituting the system named in the first project, I do not approve of. Finally, I am of the opinion that no like system designed to deflect the floods and ebbs of Bolivar channel, with the object of benefiting Galveston channel, can be judiciously introduced, nor with a satisfactory prospect of success. The particular system described and estimated for is simply presented as an example of the inadequacy and enormous cost of all like systems for the improvement in question. Should a permanent fortification be placed on Pelican spit, a breakwater will doubtless be necessary to protect the latter, or the foundations of the former, from encroachments of the sea. This will present no great difficulties.

The following considerations are respectfully submitted as against the adoption of the first project:

1st. The enormous cost, especially when considered in connection with the extent of the interests to be benefited.

2d. The ebb currents being due to the departure of the tidal wave from the mouth of the bay, producing a lower water level in the gulf than in the bay itself, and the distance from the head of the Pelican Island jetty to the mouth of Galveston channel (which distance the water

must pass over in seeking the lower level) being more than twice as great by the Galveston channel as by the Bolivar channel, it is my belief that the current attempted to be deflected will take the latter channel in spite of the jetty, cutting the Bolivar channel deeper, or widening it by encroaching on Bolivar Point sufficiently to compensate for the reduction in its cross-section produced by the jetty, thus defeating the object of the latter completely. The flood currents being principally due to the lower water-level in the main reservoir of Galveston and East bays on the arrival of the tidal wave at the seaward entrance, and the Bolivar channel being the shortest line between the two levels, the Pelican Spit jetty will likewise utterly fail in accomplishing its objects, the flood current it is designed to deflect through Galveston channel still keeping on in Bolivar channel in spite of the jetty, excavating for itself a passage between the jetty-head and Bolivar Point.

3d. Supposing the Pelican island jetty successful in enlarging the Galveston channel reservoir to the northward, there is reason to fear that if any great increase of current is thus produced, as the latter flows directly towards the Galveston city water-front, it will deflect the current which flows along this front (and which results from the two currents coming respectively from Galveston bay and West bay) in-shore, and thus endanger the wharf foundations and encroach on the site of the city. The existing concavity of the shore-line in the vicinity of the city is an indication that such an encroachment might result.

4th. Should the Pelican spit jetty accomplish the deflection of a portion of the Bolivar channel flood current sufficient to produce any material abrading effect on the Galveston channel bar, it is to be feared that, in addition to the danger of damage by storms due to its exposed position, the jetty would be liable to be undermined by the deflected current itself, especially the portion comprised between the 6-foot and 12-foot curves of the shoal. Insurance against these dangers could be accomplished only by adding security to the foundations at great expense.

Project of a dam closing San Luis Pass.

For position of the dam, see chart F; and for detailed estimates of its cost, reference is made to Lieutenant Stanton's report. It is probable that the small channel north of Mud island, and uniting Bastrop bay with West bay, would have to be closed. No opportunity was afforded of examining this channel, but it is thought to be insignificant, if, indeed, it exists now at all.

The aggregate cost of this system of dams is estimated at $330,000.

It is proposed to carry the dams full four feet above the level of ordinary low-water, since the water rises, under the influence of certain combinations of tides and winds, three feet eight inches above that level.

The effect of this plan would be to increase the area of the Galveston channel reservoir by 36.86 square miles, which, added to its present area of 58.68 square miles, gives a resulting area of 95.54 square miles. These estimates include that portion of the area of Galveston bay proper situated southwest of the Pelican shoals and the line A B, (chart F.) An increased volume of water should thus be made to flow through Galveston channel; the increase for each flood and each ebb amounting to 1,130,357,606 cubic feet, estimating for a rise and fall of one and one-tenth foot, which is the mean for the year.

Of all plans for deepening and maintaining the channel across the inner bar, thus accomplishing the proposed improvement and preserva-

tion of the inner harbor, by means of increasing the abrading efforts of the tidal currents, this is the most legitimate and judicious. I can foresee no injurious effects which would be likely to result from its adoption. I do not recommend its adoption, however, for the following reasons:

1. The cost is too great when considered in connection with the extent of the interests to be served, and the maximum amount of benefit which it is possible for the harbor to receive without also improving the outer bar channels. The present channel depth across the outer bar is but 12 feet, and the crest line of the latter, along the entire extent of which the tidal currents are disseminated, has so great a development that little if any increase of channel depth can be anticipated across it from the increase of reservoir proposed. The present depth on the inner bar being about nine feet, the extent of possible useful improvement upon it is therefore limited to about three feet increase of channel depth. Had the outer bar a channel depth of 18 or 20 feet, the estimated expenditure might be more justifiable with the object of accomplishing a like depth on the inner bar, thus placing Galveston on an equality with most first-class harbors.

2. The average rise and fall of the tide at Galveston entrance being but one and one-tenth foot, and during the periods of highest tides there being but one tide a day, giving limited current velocities, and considerable and oft-recurring intervals of still water as far as tidal influences are concerned, a serious doubt arises as to the possibility of accomplishing the desired improvement by this or any other plan for increasing reservoir areas. So weak are the tidal currents (see current observations, chart E, and digest of the same in Lieutenant Stanton's report) that an ordinary stiff, steady breeze in a contrary direction will ordinarily neutralize them entirely. The principal changes on this coast are sudden, and due to violent storms, which in a few hours often obliterate sand shoals, deposit others, and move others bodily from place to place. The ordinary changes due to the tidal currents, and, on the open beach, the fair weather waves, are so gradual as to be perceptible only by comparing observations taken at intervals of several years. The following notes are taken from a "Chart of the coast of Texas in the vicinity of Galveston," "hydrography under direction of Lieutenants Commanding A. S. Baldwin, T. A. Craven and E. J. De Haven, U. S. N., assistants United States Coast Survey, 1856:"

The rise and fall at the entrance of Galveston bay is usually small. The time and height of high and low water are irregular, and much influenced by the direction and force of the wind.

The average rise and fall from 12 months' hourly observations in 1851–'52 was 1.1 foot.

The height of high water above the plane of reference—mean low water at the time of the moon's greatest declination, 1.3 foot.

The height of high water above the plane of reference at the time of moon's least declination, 0.8 foot.

The rise of highest tide observed above the plane of reference, 3.8 feet.

The fall of lowest tide observed below the plane of reference, 1.8 foot.

When the moon's declination is zero, or very small, there are two small irregular tides in 24 hours; but as the moon's declination increases north or south, the rise and fall increase, and the two become more and more unequal, until one high and one low water can be recognized in 24 hours. This is the case for from three to four days before to as many after the time of the moon's greatest declination. During that period the tide rises from low to high water in about eight hours, stands at its greatest height from one to one and one-half hours, then falls about half a foot in five or six hours to stand again, sometimes with a slight rise for from two to four hours, after which it falls regularly to low water in eight or nine hours. Sometimes the water falls very slowly for the nine or ten hours following high water, and then more rapidly to low water. These remarks suppose that there is no disturbing action of the wind.

Even if the currents were sufficient to justify the belief that their centration would result in a decided increase of their abrading effort, re is no certainty that this effort would not be expended in widening channel instead of deepening it, or enlarging some new channel lia- to be opened at any time by violent storms.

enerally it may be urged in objection to all systems of dams, jetties breakwaters, designed to improve or preserve channel and harbor ths on the Texas coast, that in consequence of the ease with which loose materials composing the coast itself, and the contiguous shoals islands, are shifted by the frequent and powerful storms which pre- there, no certainty of their accomplishing the results proposed can ntertained. Even if they succeed temporarily, changes calculated ender them useless are at all times imminent. Supposing either of two projects just discussed to have been executed, and that a storm eries of storms increased the depth of the breach made across Gal- ton island, near Fort Point, by the storm of last October, (see Lieu- ant Stanton's report, and yellow shore-line, chart C,) to 6 or 8 feet, s dividing the current between the old and new channels, this con- gency would neutralize the effect of either system, and render either lging operations, or an extension of the old system, or the introduc- of an additional new system of works necessary. Or the old chan- might close entirely, rendering the Pelican spit jetty (in case the system had been adopted) entirely useless, and the money spent in construction a dead loss. The erection of sea walls on the open ch, or exposed to waves from the open sea, having sufficient stability ender such a contingency impossible, I regard as out of the question hin means likely to become available for such an object.

OJECT OF EXCAVATING OR DREDGING BY MEANS OF MACHINERY.

his is in my opinion the most judicious and efficacious plan possible, it involves the least expense.

channel 80 feet wide and 12 feet deep, excavated across the inner on the most favorable line, would be ample for the passage of sail- vessels singly and steamers meeting or passing each other in it. It uld be distinctly marked, a line of spar buoys, at intervals of say 400 ls, being placed just outside the edges on each side with can-buoys he ends, in order that the limits may be visible in ordinary fogs. amount of excavation for such a channel is estimated at 5.476 cubic ls. (See Lieutenant Stanton's report.) I have no definite data on ch to base the cost per cubic yard. Two dollars ought, I think, to ice, especially if the work should be done during the summer months, ch are the freest from rough weather. At this rate the cost of the rovement would be $10,952. I think there would be no difficulty btaining a contract for a series of years to effect and maintain the rovement at the rate of $20,000 per annum, or perhaps even a little , provided the contract took liberal account of the interruption of k during the stormy months.

he great specific gravity of the material to be excavated, which is d, and the feebleness of the current, would render success by any n of stirring or floating up the material, with a view to the current ying it away, doubtful. Osgood's patent dredging machine is, as I reliably informed, successfully used on the Pascagoula bar for depths 0 feet, the bar being of sand. The machinery which so successfully pened the Clyde and Tyne rivers in Scotland, working to a depth of

30 feet, would, I think, answer well for this work. It is of simple construction, being merely an application of the principles of the common grain-elevator.

Very respectfully, your obedient servant,

M. D. McALESTER,
Brevet Brigadier General U. S. A., Major of Engineers.

Brevet Major General A. A. HUMPHREYS,
Brigadier General and Chief of Engineers, Washington, D. C.

UNITED STATES ENGINEER OFFICE,
New Orleans, June 24, 1868.

GENERAL: The ninth paragraph of your memorandum of instructions of May 15, 1867, for my guidance in conducting the examination and survey of Galveston harbor requires me to "ascertain as far as practicable the character of Pelican spit and its substrata, and the changes it is liable to and will be likely to suffer in the event of the introduction of any dams or breakwaters thought necessary to be introduced for the improvement of the inner bar and the preservation of the harbor proper and the channel by which it is entered."

In compliance therewith I have the honor to submit the following report:

Pelican spit is an island 1,700 yards long with a maximum and minimum width of 270 and 100 yards. For about two-thirds of its length from its northern extremity its width is not less than 220 and averages about 265 yards. It is a deposit of exceedingly fine sand and has been formed since 1840, upon the shoal extending, then, as now, from Pelican island seaward nearly to the entrance of the bay. Its highest point at present is not more than four feet above the plane of mean low water. Borings made to as great a depth as practicable with the means at hand, ten feet below the plane of mean low water, (see boring I, chart E, accompanying report on Galveston harbor,) reveal no change in the character of the soil, the same quality of sand as at the surface being found throughout that depth. Blue and yellow clay were found in the vicinity of the upper end of Pelican island at an average depth of 20 feet, (borings A C and D, chart E.)

According to the report of Captain G. B. McClellan, of April 18, 1853, (Ex. Doc. 1853 and 1854, part 2d, vol. 1, page 560,) a stratum of blue clay crops out along the coast in about seven and a half fathoms of water. Supposing that the clay found above Pelican island belongs to the same stratum, which is somewhat doubtful, and that the stratum has a uniform inclination, it is estimated that it is situated at Pelican spit 25 feet below the plane of mean low water.

On chart C, accompanying report on Galveston harbor, it will be seen that the island has moved west about 400 yards since first surveyed in 1851, retaining very nearly its original size and form. A comparison of resurveys made early in 1867 and in April last (see black and yellow shore-lines, chart C) indicates that this movement westward is still in progress. The island, located just within the entrance to the bay, is much exposed to the action of heavy seas from the Gulf, during strong easterly and northeasterly winds, and to the ordinary flood currents. Through these agencies its eastern shore is constantly receding, while its west shore appears to advance with about the same rapidity, a deposit being gradually formed there, probably during ebb tide in consequence of the diminution caused by the island in the velocity of the

water above it. Bolivar channel is also encroaching on the north shore. The most extensive changes are produced by storms. Those caused by the action of the ordinary currents occur so slowly and gradually that they can be perceived only by a comparison of surveys made at long intervals. During the storm of October last, one of the most severe which has visited this part of the coast in many years, the northern part of the east shore of the island receded about 130 feet; the wharf and all the buildings, three in number, and the casemated defensive work situated at the northeast corner of the island, (described in my report of June 22, 1867,) were entirely demolished and all their material swept away by the sea. The 42-pounder and the two 32-pounders which formed the armament of the work are now scarcely visible above the surface of the water. A barbette battery formed of sand, and containing one unserviceable 9-inch naval gun, is the only work remaining on the island. Should an attempt be made to improve the harbor by the introduction of a system of jetties, the lower jetty would protect the east shore of the island against the flood current and heavy seas from the Gulf, and stop the encroachment at present in progress there, while improvement by the introduction of a dam at San Luis Pass would probably hasten this encroachment in consequence of the large increase (1,130,357,606 cubic feet) in the volume of water flowing through Galveston channel.

Should Pelican spit become the site of a permanent work I think it will be necessary to protect both its east and north shores by breakwaters.

Respectfully submitted.

W. S. STANTON,
First Lieutenant Corps of Engineers.

Brevet Brig. Gen. M. D. McALESTER,
Major Corps of Engineers, New Orleans.

I 5.

UNITED STATES ENGINEER OFFICE,
New Orleans, May 29, 1868.

GENERAL: In compliance with your instructions of May 15, 1867, I have the honor to submit the following report:

In your order of the above date I am required to proceed to Galveston, Texas, and direct the examination and survey (to be made by a Coast Survey party) necessary to determine the best plan for improving and preserving Galveston harbor, in accordance with a memorandum of instructions furnished me; and in the 8th paragraph of the letter to report the best and most feasible plan, in my judgment, for obtaining and maintaining upon the inner bar as great a depth of water as is found in the outer bar, and for preserving the harbor against encroachments, (in case it is liable to them,) with estimates of the cost of its execution.

I repaired to Galveston, May 22, on the completion of my duties in this city; but owing to the delay, occasioned by stormy weather, in the arrival of the coast survey party from San Luis Pass, the survey was not commenced until June 4. Between that date and July 8 the soundings and the resurvey of the shore-line were completed within the limits designated in your instructions, viz: the shore of Galveston island, the meridian of the eastern extremity of Bird Key, an east and west line passing through Half Moon Shoal light-house, the west shore of Galveston bay, and to include Deer island in West bay. Over the entire area

included within these limits the depth of water and character of the bottom were ascertained. The shore line of Pelican spit and island, of the northeastern extremity of Galveston island, and of the southwestern extremity of Bolivar peninsula only, were resurveyed, as these portions embrace all that part of the shore line of the bay where important changes had taken place since the original survey of 1850–'56. Such current observations as could be made, while the soundings were in progress, were also taken at this time. For a detailed account of the progress of the survey during this period, which was considerably retarded by unfavorable weather, I would refer to my report of August 12. In accordance with your orders, and with instructions received from the Coast Survey office by Sub-Assistant Nes, in charge of the party, operations were suspended on the 8th of July. I then gave Sub-Assistant Nes, by your orders, detailed instructions (copy transmitted with report of August 12) for the preparation in Washington of three charts of the bay within the above limits. These charts, received here in November last, were prepared on a scale of 1-20,000, and are lettered A, B, and C. A is a chart of the original survey of 1850–'56; B of the resurvey of 1867, fully embodying all the facts ascertained up to July 8; and C is a comparative chart formed by combining A and B upon one sheet. A copy (lettered D) on a scale of 1-10,000 of that portion of the chart C embracing only the inner bar and harbor proper, was also prepared in the Coast Survey office, in accordance with subsequent instructions.

Early in January last operations were resumed by the coast survey party of Sub-Assistant Halter, under detailed instructions from this office of January 1. January 30, by your order, I repaired to Galveston to take immediate charge of the work; informed on my arrival there, by Sub-Assistant Halter, that he was about to withdraw his party under orders from the chief of the Coast Survey, I was compelled to return to this city for the necessary facilities to complete the survey. March 3 I again resumed it with a vessel and party chartered and organized by your orders.

Sub-Assistant Halter having again reported with his party, on March 14, proceeded with the survey under my orders. On the 20th I discharged my own party, deeming the additional expense it entailed not justifiable by the gain in time. While employed, it had made the borings necessary to determine the character of the substrata near the northwest extremity of Pelican island, and had commenced the current observations in that vicinity. Its operations were very much interrupted and retarded by stormy and unfavorable weather.

The coast survey party completed the borings and current observations, and again made a survey of Pelican spit and the northeast extremity of Galveston island, which important changes, produced by a violent storm in October last, required. April 9 the examination and survey was completed, and the coast survey party relieved from duty in connection with it. The results of this year's operations, current observations and borings, and also of the current observations made by Sub-Assistant Nes in June and July, 1867, are embodied in chart E. Three additional charts, lettered F, G, and H, are herewith transmitted. Chart F is a tracing of the coast survey chart of 1856, showing the relative areas watered by Bolivar and Galveston channels, and of East, West, and Galveston bays, also the proposed location of the dam at San Luis Pass, hereafter referred to. Charts G and H were obtained in Galveston. The former is a copy of a survey of the inner bar, made in 1865 by Lieutenant McGregory, volunteer engineers. The latter is a copy of a

and imperfect chart of the harbor, made in 1841 by Commo-
e, of the Texas navy.
ge inlet from the gulf at Galveston, comprising the three arms
Galveston, East and West bays, (see chart F,) has an area in
ollows:

bay, extending from the city 30 miles north, to the mouths of Jacinto and Trinity rivers.....	346.88	square	miles.
extending 20 miles to the northeast from on bay, and parallel to the general coast	75.44	"	"
extending 22 miles to the southwest....	69.66	"	"
gate area of the inlet in square miles....	491.98		

from this the area (36.86 square miles) of that part of West
of Caronkaway Point, which is supplied through San Luis
e remains an area of 455.12 square miles over which the tide
ebbs through the entrance between Galveston island and Boli-
ula. Of this area it is estimated, although somewhat imper-
t the two channels, Galveston and Bolivar, into which the
is divided by Pelican island and spit, and the immense shoal
n, supply respectively 58.68 and 396.44 square miles, the former
southwest, and the latter northeast of Pelican island, and the
hart F) approximately determined as the line along which the
hese channels commingle and separate at flood and ebb tides.
vo channels unite, their axes intersecting nearly at right angles,
the line joining the opposite points of Galveston island and
ninsula. Bolivar channel has a cross-section of 109,505.55
t; is a short, direct, and the main communication between the
bay; while Galveston channel, from its small cross-section,
quare feet,) circuitous form, and the direction of the current at
referred to Bolivar channel and the coast line, is naturally of
importance. The inner bar, extending across this latter chan-
unction with Bolivar, is a deposit consisting of a stratum three
of exceedingly fine sand, resting upon a stratum of very fine
mall fragments of shells, mixed. The harbor proper obstructed
is 6,000 yards long and only 250 yards wide, measured within
curve, affording to ships of 12-feet draught very scant space
about.
rtained by borings made to as great a depth as practicable
neans at hand, from seven to eighteen feet below the surface of
water, (chart E, borings E, G, H and I,) the surface and sub-
at the entrance to the harbor are composed of very fine sand.
northwest end of Pelican island clay was found at an average
) feet, the surface stratum being composed principally of very
nixed with a small quantity of sand.
G. B. McClellan, in his report of April 18, 1853, (Ex. Doc.,
art 2, vol. 1, p. 560,) states that "the bottom of the gulf along
(Texas) coast deepens very gradually, and is of sand until you
epth of about seven and a half fathoms, where blue clay is

comparison of the various charts of this harbor, above men-
l from information obtained of the best informed pilots and
Galveston, it appears that important changes, according with
nown change in the character of the channels along this entire

coast, have been in progress at the mouth of Galveston channel since about 1841. At that time (chart H) the water had a uniform depth of 30 feet from the wharves at Galveston, through Galveston and Bolivar channels, till it commenced shoaling at the outer bar, upon which then, as now, its depth in the channel was 12 feet. If charts B and H, be compared, it will appear that the northeast end of Galveston island has been cut away about 1,100 yards, and that a deposit, comprising the inner bar, has been formed, extending from the point X, (chart H) near the former end of the island, across the channel and upon the shoal on its other side, embracing Pelican spit, which was not visible above the surface of the water in 1841. The questionable accuracy of chart H has caused considerable doubt regarding the actual occurrence of changes so extensive as these. It is dispelled, however, by information obtained of the citizens of Galveston, several of whom state that within their recollection the water has been 30 feet deep where the inner bar now is. The northeast extremity of Galveston island has been washed away about one-half a mile, and Pelican spit has appeared above the surface of the water.

Lieutenant W. H. Stevens, formerly of the corps of engineers, in his report of September 30, 1853, on Galveston bar, (Ex. Doc., 1853–'54, part 2, vol. 1, p. 560,) states that "the channel between Pelican shoal and the east end of Galveston island is filling up. Where 30 feet was found in 1841, there is now but 12. This filling up seems to be due to the cutting away of the east end of the island by the southeasters; the point once extended to the south buoy."

This filling up was first observed in 1843, when the pilots reported that "a lump" was forming in Galveston channel, near its junction with Bolivar. This deposit, I have been informed, increased very steadily and uniformly until September, 1854, when the depth of water on it had diminished to about 10 feet. In that month a violent storm cut away its crest, making a channel across it 15 feet in depth. From the survey of Lieutenant McGregory, (chart G,) it appears that this depth diminished only one foot during the next 11 years, there being, according to that chart, 14½ feet of water on the inner bar in 1865. Early in 1867, Sub-Assistant Boyd, United States coast survey, found only 9½ feet of water there at mean low tide, its present depth; from this it appears that a deposit 4½ feet thick was formed during 1866. Obstructions were introduced by the rebels in 1863 along the lines A B, and C, D, E, (chart B.) In the former locality they consisted of three rows of piles, 20 inches in diameter, extending across the channel between A B. The piles were 12 feet distant in each row, and the rows six feet apart. Each of the rows supported a large chain, its ends being anchored to large masses of railroad iron sunk in the sand at B, and in a crib in four feet of water at A. These piles were all removed within two years after their introduction, through the agency of worms, and partially by mechanical means. The crib, filled with iron and bricks, still remains. Along the line C, D, E, approximately, 14-inch piles were driven in triangular-shaped groups of three. The piles in each group were driven in juxtaposition, and the groups were 20 feet apart. An interval of 60 feet was left between the groups in the deepest water. These piles, with but a few exceptions, have long since been removed by the worms.

Some information which I have obtained would seem to indicate that the shoal between Galveston and Bolivar channels has been gradually increasing, and thus filling up the harbor for many years past. It appears that in 1841 (Note, chart H) Galveston channel was 365 yards wide, measured from the ends of the wharves to the 12-feet curve on the other side; while at present its width, measured between the same

points, is only 250 yards. Moreover, it is said by the citizens in Galveston that Pelican island has appeared above the surface of the water within the present century. A comparison, however, of the cross-sections of Bolivar and Galveston channels, taken on the lines A B and C D, (chart C,) shows that the cross-sections of the former channel have increased 12,659.35 square feet, and that of the latter, 3,765.4 square feet since 1851. The increase in width of the two channels on those lines during the same time, is respectively, 586 and 313 yards. It thus appears that the cross-section of Bolivar channel has increased in the greater ratio, and that Galveston channel, near its mouth, is becoming wider and more shallow. On chart C it will be seen that this increase in width is gained by encroachment on Pelican spit, which, since 1851, has moved parallel to itself about 500 yards nearer Pelican island, retaining very nearly its original size and form. The change in this island is so peculiar that it was at first thought it might have been incorrectly located in the original survey; but a re-survey of its present shore-line (traced in yellow on chart C) made last month, and compared with the survey of it made early in 1867, showing that the change is still in progress, proves that it has actually occurred. This change since 1867 in the eastern shore-line of the island was produced principally during a violent easterly gale in October last. It was one of the most severe ever witnessed in Galveston; the wind rose in the southeast and gradually shifted to the northeast, in which quarter it abated; the water accumulated in the harbor, rising to the height of two feet in the streets three blocks from the wharves; ships of 100 tons were driven up between the wharves and left, after the subsidence of the gale, above the low-water mark. On Pelican spit the wharf and all the buildings were swept away. This encroachment on the eastern shore of this island, it is probable, is also partially caused by the currents during ordinary flood-tides which then flow directly towards it, and are by it deflected into the two channels (chart E.) At ebb tide a deposit is probably made on its west shore in consequence of the diminution which occurs in the velocity of the water covering the shoal between it and Pelican island. On this shoal the water is from 18 to 30 inches deep at high tide; the bottom is in many places muddy and covered with a growth of marsh grass. This attrition and accretion appear to be exactly compensating, and thus to account for the change in the location of the island. By comparing along the line C, D, (chart C,) the present position of the 18, 12, and 6-feet curves, and of the shore-line of Galveston island, with their positions in 1851, it will be seen that at this point Galveston channel has shifted from Galveston island towards Pelican spit. This change in the position of this channel is considered very injurious, inasmuch as it brings its mouth still more at variance with the general direction of the ebb and flood currents in Bolivar channel and along the coast, thereby diminishing the velocity and scouring force of its own currents, and increasing the agencies which it is thought produced the inner bar.

In consequence of the limited time allotted to the survey, the extreme irregularity of the tides and currents which are almost wholly dependent upon the strength and direction of the wind, and the want of facilities for taking them simultaneously at the different stations, the current observations are not as numerous or satisfactory as desirable. Enough, however, have been made to determine the direction and relative velocity of the currents at the most important points.

The following are the results obtained by taking a mean of all the observations made during each of the first three quarters of the flood and ebb tides along the lines A, B, C, and P, O, N, M, in Galveston and

Bolivar channels, respectively, and along the lines D, E, F, and J, K, L, just without the entrance to the harbor. The velocities are expressed in statute miles per hour, (chart E.)

On line A, B, C.

Velocity of current at surface, 1st quarter, flood tide	0.85
Velocity of current at surface, 2d quarter, flood tide	1.433
Velocity of current at surface, 3d quarter, flood tide	0.525
Average velocity of current at surface during flood tide	0.936
Velocity of current 12 feet under surface, 1st quarter, flood tide	0.7
Velocity of current 12 feet under surface, 2d quarter, flood tide	1.5
Velocity of current 12 feet under surface, 3d quarter, flood tide	0.2
Average velocity of current 12 feet under surface, during flood tide	0.8
Velocity of current 9 feet under surface, 1st quarter, flood tide	0.4
Velocity of current 9 feet under surface, 2d quarter, flood tide	0.3
Velocity of current 9 feet under surface, 3d quarter, flood tide	0.1
Average velocity of current 9 feet under surface, during flood tide	0.266
Mean velocity of cross-section A, B, C, during flood tide	0.667
Velocity of current at surface, 1st quarter, ebb tide	0.92
Velocity of current at surface, 2d quarter, ebb tide	2.35
Velocity of current at surface, 3d quarter, ebb tide	0.366
Average velocity of current at surface during ebb tide	1.212
Velocity of current 9 feet under surface, 3d quarter, ebb tide	0.266
Velocity of current 12 feet under surface, 2d quarter, ebb tide	.23
Velocity of current 12 feet under surface, 3d quarter, ebb tide	1.925
Mean velocity of cross-section A, B, C, during ebb tide	1.126

Observations on line P, O, N, M.

Velocity of current at surface, 1st quarter, flood tide	2.375
Velocity of current at surface, 2d quarter, flood tide	1.3625
Velocity of current at surface, 3d quarter, flood tide	0.68
Average velocity of current at surface during flood tide	1.4725
Velocity of current at surface, 1st quarter, ebb tide	0.925
Velocity of current at surface, 2d quarter, ebb tide	2.35
Velocity of current at surface, 3d quarter, ebb tide	1.45
Average velocity of current at surface during ebb tide	1.575

Observations on line J, K, L.

Velocity of current at surface, 1st quarter, flood tide	0.4
Velocity of current at surface, 2d quarter, flood tide	1.7
Velocity of current at surface, 3d quarter, flood tide	1.63
Average velocity of current at surface during flood tide	1.243
Velocity of current at surface, 1st quarter, ebb tide	0.53
Velocity of current at surface, 2d quarter, ebb tide	1.7
Velocity of current at surface, 3d quarter, ebb tide	0.8
Average velocity of current at surface during ebb tide	1.01

Observations on line D, E, F, G.

Velocity of current at surface, 1st quarter, flood tide	0.86
Velocity of current at surface, 2d quarter, flood tide	1.4
Average velocity of current at surface during flood tide	1.13
Velocity of current at surface, 2d quarter, ebb tide	0.7
Velocity of current at surface, 3d quarter, ebb tide	0.65
Average velocity of current at surface during ebb tide	0.675

From the above figures it will be seen that the relative surface velocities at these four points during the two tides are as follows:

	Flood tide.	Ebb tide.
Entrance to bay, (line J, K, L)	1.243	1.01
Bolivar channel, (line P, O, N, M)	1.4725	1.575
Entrance to bay, (line D, E, F, G)	1.13	0.675
Galveston channel, (line A, B, C)	0.936	1.212

From which it appears that the ebb current is more rapid than the flood, excepting in the side channel near the outer shore of Galveston island, and that the least velocity during flood tide is at the entrance to Galveston channel near and on the inner bar. In consequence of this diminution of velocity at this point, due to the direction in which Galveston channel presents its mouth, more sand is probably deposited during the flood tide than the scouring action of the ebb current can remove, thus causing the formation of inner bar.

From its location this bar is but little exposed to the action of heavy seas from the gulf, and with the remarkable exception of the gale in September, 1854, which increased the depth of water upon it from 10 to 15 feet, it has been but slightly affected by storms since its formation. The most important changes they produce are confined to the shore-line in the vicinity of the entrance to the harbor, chiefly at the northeast end of Galveston island. During the storm in October, 1867, a channel, varying in width from 1,100 to 1,650 yards at high water, (see yellow shore chart C,) and varying in greatest depth at low water from one to two feet, was cut across this island at a distance of 1,000 yards from its northeast extremity, while the gulf shore-line of the portion thus isolated receded about 80 yards. But no perceptible change was produced in the bar itself. From the report of Lieutenant Stevens, the statements of citizens of Galveston and chart C, it appears that the narrow body of land, about 2,300 yards in length, running nearly north and south and constituting the northeast extremity of Galveston island, has been gradually washing away under the action of easterly storms for many years. By the storm of October, 1867, more than one-half of this part of the island was converted into a shoal. And I think there is reason for apprehending that, unless something is done to restore and preserve the original form of the island here, the remaining isolated portion will soon be washed away; that Galveston channel will take, under the action of seas from the gulf and its ebb current, a more direct course to the sea, bringing its mouth nearer the island; and that it will become in consequence of its largely increased width (from 1,250 to 2,150 yards between Pelican spit and Galveston island) even more shallow than it is at present on the inner bar. Whatever mode of improvement is ultimately adopted, I think these changes should be arrested and carefully guarded against; especially as the distance, two and a quarter miles from the 12-feet curve within the harbor across the island to the 12-feet curve without, and the width of the new channel, would seem to preclude the possibility of its becoming navigable for

vessels of 12 feet draught. The distance across the inner bar between these curves is 450 yards.

Three different methods of obtaining and maintaining the required depth (12 feet) of water on this bar present themselves, viz: first, by increasing the volume of water flowing through Galveston channel during flood and ebb tide by the introduction of two jetties, one extending from the shoal east of Pelican spit northeast into Bolivar channel, and the other from the northwest end of Pelican island north by east into the same channel; second, by introducing a dam at San Luis pass to increase the reservoir supplied and emptied through Galveston channel, by the addition of that part of West bay west of Caronkaway Point; third, by dredging.

In compliance with your directions, I submit the following detailed estimate of the cost of improvement by each of the first two methods:

IMPROVEMENT BY THE INTRODUCTION OF JETTIES.

The following is a description of a jetty for this harbor, which is believed to unite in the best manner economy with durability: When the water exceeds about six feet in depth, the jetty is to be formed by confining blocks of concrete $6' \times 2' \times 2'$ between two rows of eight-inch mangrove piles, driven four feet apart from center to center. The distance between the rows and the consequent cross-section of the jetty will depend, of course, upon the depth of water. Each row of piles is to be capped with eight-inch by eight-inch timber notched and spiked to each pile. Cross-ties of six-inch by six-inch timber are to be placed 12 feet apart from center to center, and notched and spiked at each end to the capping pieces of each row of piles. Those portions of the jetties situated on shoals where the water is less than six feet in depth, are to be formed by driving mangrove piles six feet apart from center to center, in two rows, about 14 inches asunder. The space between these two rows is to be filled with a tier of palmetto logs, which average about one foot in diameter at the butt. Each row of piles is to be capped by six-inch by eight-inch timber, and cross-ties of the same dimensions are to be placed 12 feet apart and notched and spiked at each end to the capping pieces of each row of piles. Mangrove is the best timber for the piles, as it is never attacked by worms, and will decay only after a large number of years. The worms (*Teredo navalis*) will destroy a pine pile in Galveston harbor in about three years. Palmetto is considerably cheaper than mangrove, and as it is only very slowly eaten by the worms, may be used to fill the space between the rows of piles. Mangrove piles 30 feet long and palmetto logs can be delivered in Galveston, from Florida, at a respective cost of not more than 35 cents and 25 cents per running foot.

The following estimates are made for jetties of the above description:

Estimate for jetty extending from the northwest end of Pelican island into Bolivar channel.

The site of this jetty is indicated by the line R T V, (chart E;) its outer end is to rest on the northwest extremity of the series of shoals in Bolivar channel; and it is designed to turn the water flowing at ebb tide through the channel between these shoals and Pelican island into Galveston channel. The entire length of the jetty, including the circular jetty-head, 50 feet in diameter, will be 6,650 feet. The portion, 2,000 feet long, extending from Pelican island to the point T in eight feet of water is to be formed of logs, and that portion between T and V, 4,650 feet long, of concrete, as above described. The comparatively smooth sea found at all times at this point in consequence of the protection afforded

by the surrounding shoals, it is thought will admit the extension of the log jetty into eight feet of water.

The character of the substrata in this vicinity is exhibited on chart E by borings A B C and D. Tough, blue, or yellow clay is found at an average depth of 19 feet below the plane of mean low water. Along the line of the jetty from Pelican island 1,000 feet to the six-feet curve, the bottom is hard, consisting of a stratum of sand mixed with mud; the proportion of mud increases with the depth until the clay is reached. From this point to the six-feet curve at the shoal upon which the jetty-head rests, the bottom consists of a stratum of very soft mud—so soft that a man can easily push a pole into it to the depth of five or six feet; but it gradually becomes harder as the depth increases until the clay is reached. Along the concrete portion of the jetty the depth of water varies from eight to 12 feet, and averages 10 feet. The jetty is designed to extend two feet above the plane of mean high water.

In view of the character of the bottom and the distance it will settle, the average cross-section of the jetty is assumed, for the purpose of the estimate, to be 20 feet by 20 feet.

Estimate for log portion of jetty, 2,000 feet long.

For 334 mangrove piles, 25 feet long, (for first 1,000 feet from Pelican island,) at 35 cents per running foot	$2,922 50
For 334 mangrove piles, 30 feet long, (for second 1,000 feet from Pelican island,) at 35 cents per running foot	3,507 00
For driving 668 piles, at $2 per pile	1,336 00
For 26,000 running feet palmetto logs, at 25 cents	6,500 00
For putting in position 1,300 palmetto logs, 20 feet long, (26,000 running feet,) at $1 per log	1,300 00
For 18,340 feet (board measure) of 6-inch by 8-inch timber for capping pieces and cross-ties, at $25	458 50
For 565 pounds of 8-inch spikes, at 10 cents	56 50
For cutting and fitting capping and cross-ties, at 50 cents per pile	334 00
Cost of log portion of jetty	16,414 50

Estimate of cost of one cubic yard of concrete formed in blocks, six feet by two feet by two feet, and laid in jetty.

MATERIALS.

For 1,724 barrels cement, at $4 per barrel	$6,896 00
For 3,448 barrels sand, at 20 cents per barrel	689 60
For 2,467 barrels shells, at 24 cents per barrel	592 08
Total cost of materials for one cubic yard	8,177 68
Estimated cost of labor required to make one cubic yard, including services of carpenter, at $2 75, in manufacturing molds, and cost of rations, at 45 cents, and allowing 12 laborers, at $1 25, and one foreman, at $3, to make 12 blocks six feet by two feet by two feet, per day	2,536 00
Cost of one cubic yard ready for jetty	10,713 68
Estimated cost of transporting from Pelican spit, and putting one cubic yard in position in jetty, including rations of employés and expense of tug, at $65 per day	581 00
Total cost of one cubic yard laid in jetty	11,294 68

In the above estimate the quantity of mortar required was determined by accurately ascertaining the void space in one cubic yard of the shells to be used. They are clam-shells, and I think a sufficient quantity (250,000 barrels) for the two jetties can be procured in the vicinity of the mouth of the San Jacinto river. At the mouth of Goose creek (see chart F) is a bank containing about 125,000 barrels, accessible with a vessel of four feet draught. The proprietor will deliver them in Galveston at 24 cents per barrel. Several smaller banks are in its vicinity. Twenty cents per barrel is the probable cost of excavating the sand in Pelican spit, where the concrete will be made. It is very doubtful if enough sufficiently coarse for mortar can be found there; should beach sand from Bolivar peninsula or Galveston island be used, the cost of concrete per cubic yard will somewhat exceed the above estimate.

Estimate for concrete portion of jetty, 4,650 feet long.

For 2,340 mangrove piles, 30 feet long, at 35 cents per running foot	$24,570 00
For driving 2,340 piles, at $2 per pile	4,680 00
For 49,067 feet (board measure) 8-inch by 8-inch timber for for capping, at $25	1,226 67½
For 26,448 feet (board measure) 6-inch by 6-inch timber, for cross-ties, at $25	661 20
For 1,882 pounds 10-inch spikes, for capping, at 10 cents	188 20
For 433 pounds 8-inch spikes, for cross-ties, at 10 cents	43 30
For cutting and fitting capping and cross-ties, at 50 cents per pile	1,170 00
	32,539 37½
For 69,602.59 cubic yards of concrete, at $11.299	786,439 66½
Cost of concrete portion of jetty	818,979 04
Cost of log portion of jetty	16,414 50
Total cost of jetty at Pelican island	835,393 54

Estimate for jetty on shoal east of Pelican spit.

The site of this jetty is indicated by the line X Y Z, (chart E.) It is designed to increase the volume of water flowing through Galveston channel at flood-tide. Its entire length, including the circular jetty-head at Z, will be 3,700 feet. The first 1,600 feet, extending from the point X to Y in five feet of water, are to be formed of logs; the other 2,100 feet, of concrete. Along the log portion the depth of water averages about five feet, along the concrete portions it varies from 5 to 12, and averages 8 feet. The bottom and underlying strata, to as great a depth as could be reached with the boring apparatus, 18 feet below the plane of mean low water, are composed of very fine sand mixed occasionally with mud and clay, (chart E, borings G and H.)

Because of the much heavier seas which reach this point from the Gulf this jetty is made somewhat wider, and to extend further above the plane of ordinary high water than the jetty above Pelican island. In making the estimate the average cross-section of the concrete portion is assumed to have a base of 24 feet and a height of 16 feet. At its outer extremity is to be a circular jetty-head 50 feet in diameter.

Estimate for log portion of jetty, 1,600 feet long.

For 534 mangrove piles, 25 feet long, at 35 cents per running foot	$4,672 50
For driving 534 piles, at $2 per pile	1,068 00
For 19,200 running feet palmetto logs, at 25 cents	4,800 00
For putting in position 960 logs, 20 feet long, (19,200 running feet,) at $1 per log	960 00
For 14,664 feet (board measure) 6-inch by 8-inch timber, for capping and cross-ties, at $25	366 60
For cutting and fitting capping and cross-ties, at 50 cents per pile	267 00
For 377 pounds 8-inch spikes, for capping and cross-ties, at 10 cents	37 70
Cost of log portion of jetty	12,171 80

Estimate for concrete portion, 2,100 feet.

For 1,065 mangrove piles, 30 feet long, at 35 cents per running foot	$11,182 50
For driving 1,065 piles, at $2 per pile	2,130 00
For 22,144 feet (board measure) 8-inch by 8-inch timber, for capping, at $25	553,60
For 14,364 feet (board measure) 6-inch by 6-inch timber, for cross-ties, at $25	359 10
For 750 pounds 10-inch spikes, for capping, at 10 cents	75 00
For 193 pounds 8-inch spikes, for cross-ties, at 10 cents	19 30
For cutting and fitting capping and cross-ties, at 50 cents per pile	532 50
For 30,755.64 cubic yards of concrete, at $11.299	347,507 97½
Cost of concrete portion of jetty	362,359 97½
Cost of log portion of jetty	12,111 80
Total cost of jetty at Pelican spit	374,471 77½

As Pelican spit is much more readily accessible with vessels of from six feet to twelve feet draught than Pelican island, it is selected for the reception and preparation of material from which it may, when ready, be towed to the two jetties. A wharf 275 feet long, and temporary quarters for the accommodation of 100 men, will be required there. The steam pile-driver to be used should contain a force-pump for use where the bottom is of sand. The method of forcing down piles in sand with a pump has been almost exclusively and very successfully adopted at Galveston.

Estimate of aggregate cost of improvement by introduction of jetties.

For jetty at Pelican island, as estimated above	$835,393 54
For jetty at Pelican spit, as estimated above	374,471 77½
For wharf at Pelican spit	5,500 00
For temporary quarters on Pelican spit	3,000 00
For steam pile-driver with pump	2,500 00
For four scows, at $1,000 each	4,000 00
For tools, implements, hawsers, ropes, &c	2,000 00
For unforseen and contingent expenses	73,134 68½
Grand aggregate	1,300,000 00

IMPROVEMENT BY THE INTRODUCTION OF A DAM AT SAN LUIS PASS.

The object of introducing this dam is to increase the reservoir supplied at flood tide through Galveston channel by the addition of that part of West bay west of Caronkaway point, over which the tide now floods and ebbs through San Luis Pass.

The following calculations, made to determine the volume of water flowing through Galveston channel at cross-section C D (chart C) during a flood or ebb tide, with their results, are submitted: Area of cross-section C D (38,235.9 square feet) by its mean velocity per hour at flood-tide (352 feet) by duration of flood-tide (eight hours) equal 1,077,261,305 cubic feet.

Area of same cross-section by its mean velocity per hour at ebb-tide (599 feet) by duration of ebb-tide, (eight hours,) equal 1,831,505,727 cubic feet.

Present area (58.68 square miles) of the reservoir of Galveston channel (in square feet) by mean rise and fall of tide (1.1′) equal 1,799,494,963 cubic feet.

These calculations are quite enough; eight hours is, according to the C T chart, the mean duration of flood-tide for the moon's declination at the time the current observations were taken.

The area of that part of West bay west of Caronkaway Point is 36.86 square miles. By its addition the area of the reservoir of Galveston channel will be increased from 58.68 square miles to 95.54 square miles. The estimated increase which will thus be gained in the volume of water that flows through Galveston channel at cross-section C D during each ebb or flood tide will be 1,130,357,606 cubic feet. It is estimated that the mean velocity at this cross-section during flood-tide will be increased from 0.667 to 1.085 miles per hour.

The site selected for the dam is indicated by the red line C D E H F G, (chart F.) The entire length of the dam will be 2,290 yards. Along the 1,650 yards of the dam, which lie between the points C and H and the points F and G, the bottom is bare at very low water. Along the remaining portion, 640 yards long, between H and F the water has a maximum depth of 11 feet, but its average depth is about six feet. (See survey of 1853, chart F.)

The estimate which follows is made for a dam constructed, like the jetties, of piles and concrete.

The cross-section of that portion, 1,650 yards long, on the shoal, is assumed to have a base of eight feet and an altitude of six feet, and of that portion, 640 yards long, across the channel, a base of 16 feet and an altitude of 12 feet.

Estimate for dam, 2,290 yards long, at San Luis Pass.

For 3,435 mangrove piles, 25 feet long, at 35 cents per running foot	$30,056 25
For driving 3,435 piles, at $2 per pile	6,870 00
For 73,280 feet (board measure) 8-inch by 8-inch timber, for capping, at $25	1,832 00
For 21,975 feet (board measure) 6-inch by 6-inch timber, for cross-ties, at $25	549 37
For 2,418 pounds 10-inch spikes, for capping, at 10 cents	241 80
For 645 pounds 8-inch spikes, for cross-ties, at 10 cents	64 50
For cutting and fitting capping and cross-ties, at 50 cents per pile	1,717 50
For 224,533 cubic yards of concrete, at $11.299	253,699 84
Total for dam	295,031 26

Aggregate cost of improvement by introduction of dam.

For wharf on Galveston island	$6,000 00
For quarters on Galveston island, for the accommodation of 100 men	3,000 00
For one steam pile-driver with pump	2,500 00
For four scows, at $1,000 each	4,000 00
	15,500 00
For tools, implements, hawsers, ropes, &c	2,000 00
Estimate for dam itself	295,031 26
For unforseen and contingent expenses	17,468 74
Aggregate	330,000 00

The above estimates of the cost of improvement by the dam and jetty systems are submitted simply to convey, as accurately as possible with the data in possession, an idea of the great expense which the deepening of the channel across the bar by the introduction of any works in the harbor would involve.

It is quite possible that either method of improvement, especially that by jetties, by far the most expensive and hazardous, would involve the construction of a breakwater about 1,800 yards long along the northeast extremity of Galveston island, to prevent the increased volume of water thrown through Galveston channel at ebb-tide from flowing across that part of the island in taking its most direct course to the Gulf.

The result of the storm of October last seems to indicate that the injurious changes in progress at the northeast extremity of Galveston island should be arrested, and the original form of the island at this point restored by some such means as the introduction of groins, in order that even the present depth of water on the bar at the mouth of Galveston channel may be preserved by thus confining the channel to its present width.

Should the third, and by far the least expensive, method of dredging be resorted to, there will be 5,476 cubic yards of sand to remove in cutting a channel 80 feet in width and 12 feet deep across the bar.

Respectfully submitted.

W. S. STANTON,
Lieutenant Corps of Engineers.

Brevet Brigadier General M. D. MCALESTER,
Major Corps of Engineers, New Orleans, Louisiana.

I A.

WASHINGTON, D. C., *May* 22, 1868.

GENERAL: Your letter of the 14th of February last, addressed to me at Key West, Florida, and inclosing copies of a communication of the chairman of the Committee of Commerce of the Senate of the United States, and of petitions from the citizens of Key West, in reference to the expediency of deepening the northwest channel leading from the harbor of Key West to the Gulf of Mexico, and directing me to make the necessary examination and report upon the same, I had the honor to acknowledge on the 28th of the same month, and then stated that the examinations

would be made and the report forwarded at the earliest practicable moment.

Your letter of instructions does not direct me to give my views of the importance of opening the northwest channel to vessels of greater draught than can now pass through it, but I think it proper to state in brief that I fully concur with the petitioners in all they say with regard to the great importance to the country in a military, naval, commercial, and social point of view, of opening the channel to the depth of 18 feet, so as to permit vessels of considerable draught to avoid the circuitous and dangerous navigation, naturally incident to a route along the reef between Key West and the Dry Tortugas, and the ports of New Orleans, Mobile, Pensacola, Tampa Bay, and Charlotte harbor. A good deal might be said on this subject, but as the petitioners have sufficiently set forth the advantages of the proposed improvement, I shall now proceed to report upon the practicability of the project.

The surveys ordered by you I have had made by my assistant, Lieutenant William R. Livermore, corps of engineers, and the results would have been communicated long ere this had not the chief difficulty been in the ascertainment of the exact depth of the channel, which the winds and almost constant swells of the sea have prevented until a late date, and which I could now wish had been made more thoroughly; though I have every confidence that the results obtained are sufficiently accurate to predicate a project of work and a reliable estimate.

Submitted with this report is the report of Lieutenant Livermore with a map of his survey of the channel and the soundings; also, on the same sheet, a sketch showing the relation the channel bears to Key West, and also a sketch showing the relative advantages in regard to distance of the northwest channel at present admitting vessels drawing not more than 12 feet, over the circuitous course now taken by vessels drawing more than that depth, navigating between the ports of New Orleans, Mobile, and other Gulf ports, and Key West, Havana, and our northern ports.

The channel, it will be noticed, lies to the northwest of Key West and about eight miles distant, and the examinations, by borings and the use of the dredge-boat belonging to Fort Taylor, show that for a breadth of 300 feet, the proposed width of the channel, and throughout its whole length of 9,000 feet (the interval between the extreme southernmost point and the extreme northernmost point of the dredging necessary to attain a maximum depth of 18 feet) the character of the bottom to be excavated is a rather fine compact coral sand, a specimen of which I forwarded to you on the 7th instant.

The direction it is proposed to give the channel in any excavations which may be made is that indicated on the map, and is the same which nature has determined and which the same controlling circumstances will always materially tend to keep open to a greater degree than would be the case in any proposed new channel. In addition there is no new direction that could be given to the channel which would not involve a much greater amount of excavation and therefore of expense. To dredge the present channel for the proposed width of 300 feet and length of 9,000 feet, or for a distance sufficient to insure a depth of 18 feet, and give the banks a slope of 10 feet base to 1 foot vertical, will require an amount of excavation of about 262,000 cubic yards; whereas to cut a new channel in as short a direction, independent of the objection stated, that the same regime of existing circumstances would probably force the water to the old line of channel, the excavation would amount to about 400,000 cubic yards.

Now the question arises, supposing that the present channel should be excavated to the extent stated, is not the character of the bottom such that the channel will soon again fill up and shoal to the depth it now presents?

The soundings recently made, compared with those of previous years, show that there has already been a slight deepening of the channel from existing causes, and I think the conformation of the bars, extending as they do from east to west on the northern side of the area under view, also show, as Lieutenant Livermore suggests, that the channel has arisen from the water breaking through or crowding these bars, rather than from the sand tilting up the deep water and thus choking up the passage way. I am inclined, therefore, to the opinion that if the channel is once opened it will remain constant at about the same depth, though from the rather fine character of the sand I cannot speak decidedly on this point.

I now submit an estimate of the probable cost of opening a channel to the extent mentioned, to wit, 300 feet wide, 9,000 feet long, and 18 feet deep; at the same time leaving the banks with a slope of 10 feet base to one vertical. The cost of a dredge of sufficient capacity to do the work (that at Fort Taylor is entirely inadequate) with scows, and of a steam-tug to convey the sand to deep water, I have been enabled to ascertain by applying for the information at the Columbian foundry in New York, where they are made, and as the firm, Messrs. Morris & Cumings, took me in their tug to see the operations of their machines in deepening the docks at Jersey City, I feel confident of their ability to excavate satisfactorily in deep water and where the bottom is a stiff mud. Not, however, witnessing their operation where the bottom is a firm compact sand, which is the case in the northwest channel, I cannot speak so confidently of the capability of the machine under these circumstances. Taking, however, their own statement hereto appended as correct, that they can furnish a dredge which will excavate 2,000 cubic yards of stiff mud or 1,000 cubic yards of fine compact sand per day of 10 hours, and allowing (what will most probably prove to be the fact) that, in the case of the compact sand of the northwest channel, but 750 cubic yards could be counted on as the daily average work of the machine, I submit the following estimate as the least amount which will be needed to deepen the channel from 12 to 18 feet.*

Particular care should be taken to provide the dredge-boat with bulwarks high enough to prevent the boats being swamped in rough weather in the open sea. It should be also premised that, as the probable working days in each year will, as stated by Lieutenant Livermore, from the necessity of having tolerably calm weather, only be about 90 days, and the capacity of the dredge proposed will not average more than 750 cubic yards of fine compact sand per day, the amount of excavation required, 262,800 cubic yards of sand, would require very nearly four years in which to complete the work.

ESTIMATE.

Cost of one steam-dredge to be provided with bulwarks and of capacity to excavate 2,000 cubic yards of stiff mud, or 1,000 cubic yards of sand, in a day of 10 hours, requiring two engines of 25-horse power, each, including cost of

* The kind of dredge here referred to works with a single lever a large grappling bucket of five cubic yards capacity.

two dumping scows, capable of carrying 200 cubic yards each, (supposed to be framed at New York and put together at Key West)	$58,000 00
Cost of one steam-tug, to convey the dumping scows to the places of deposit	10,000 00
For dredge and scows, one captain, at $125 per month, four years	6,000 00
One engineer, at $120 per month, four years	5,760 00
One cook, at $2 per day, four years	2,920 00
One blacksmith, at $3 25 per day, for six months in each year, 24 months in four years	2,340 00
Six hands, including fireman, averaging $2 per day, 24 months	8,640 00
For tug, one captain, at $125 per month, four years	6,000 00
One engineer, at $120 per month, four years	5,760 00
One cook, at $2 per day, four years	2,920 00
Three hands, including fireman, averaging $2 per day, 24 months	4,320 00
For subsistence of six men, (two captains, two engineers, and two cooks of dredge and tug,) four years, at 60 cents per day each	5,184 00
For subsistence of the remaining 10 men, 24 months, at 60 cents per day each	4,320 00
For fuel for dredge and tug, averaging three cords each per day, for 90 days in each year, making 360 days in four years, at $7 per cord	15,120 00
Anchors, cordage, blacksmiths' tools, &c	1,000 00
Add 20 per cent. for repairs and contingencies	27,657 00
Total amount of estimate	165,941 00

Should two dredge-boats be used, one tug being deemed sufficient to attend to both, the work could be completed in half the time, or two years. The above estimate should, on this supposition, be increased to $58,000, the cost of the additional dredge and two scows, less $15,224, or half the expense of running the tug, making total amount of estimate, including 20 per cent. for contingencies, $217,272.

I cannot close my report without expressing my obligations to Captain Robert Platt, commanding United States Coast Survey steamer Bibb, for the valuable service he rendered the engineer department in towing the dredge-boat belonging to Fort Taylor, to and back from the northwest channel.

I am, general, very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel Engineers, Brevet Brigadier General U. S. A.

Major General A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

UNITED STATES ENGINEER OFFICE,
Key West, Florida, May 7, 1868.

GENERAL: I have the honor to submit the following report of a survey of the northwest channel of Key West harbor, made by me during the months of March and April, 1868.

Owing to the roughness of the sea and high winds, we were enabled to get only about three days of weather suitable for taking accurate soundings—in all about 13 hours. It was therefore thought best to make a careful survey of the most important points, and supply the rest from an old chart of the coast survey made by Lieutenant John Rodgers, United States navy, in 1851. The scale of this chart is $\frac{1}{20000}$, and as it agrees closely with our own chart, and with a few trial soundings made in parts supplied from it, no great error can arise from assuming it to fill out the places indicated by the red figures on the chart, particularly as the bottom is here quite uniform and not more than a foot of excavation will be required in any part of this area so supplied.

The soundings indicated in black were all made under my own personal supervision, and each one is carefully located by a sextant observation.

The bottom is composed of compact coral sand, a specimen of which accompanies this report, being some that was taken from the bottom by the dredge belonging to Fort Taylor. This extends at least to 18 or 20 feet of water in the proposed line of the channel, and probably much deeper.

The instrument employed to examine this bottom was a wooden pole about 20 feet in length, furnished at the end with a pointed iron rod three-eighths of an inch in diameter, and projecting five feet beyond the end of the pole. This was thrust down to the shoulder where it joins the wood, and a little further in some places; but on the eastern edge of the mud bank, indicated on the chart, after thrusting it through one foot of sand, it fell of its own weight until the shoulder struck the sand, showing that the mud underlies the sand there.

The rock is of the same nature as the Key West oolite and covered with a thin coating of seaweed and coral.

The tidal currents run at the rate of about three miles per hour, and are indicated by arrows on the chart.

The proposed direction for the channel has been made to follow as nearly as possible the natural form of the bottom, both to require the minimum amount of excavation and from the supposition that it will be more likely to remain open after being excavated; for it appears from the direction of the currents and the form of the banks that the channel has been worn by the tidal currents, after the bank was formed, and is still deepening from their action, and the tradition of the pilots confirms that view.

Two other lines running northwest and southeast have been suggested to me by officers of the navy and of the coast survey, as offering a more favorable direction for vessels leaving the harbor on account of the prevailing winds, which they assume to be northeast. But the comparison of meteorological observations for a series of years, from 1828 to 1867, shows the resultant of the direction of the winds for the different months to be as follows: January, north-northeast; February, northeast; March, east-northeast; April, east; May, east-southeast; June, southeast; July, southeast; August, southeast; September, east-southeast; October, east; November, east-northeast; December, northeast. So that for nine months in the year this objection fails to apply, and during the three months when the prevailing winds are from the northeast, it is by no means constant from this quarter, but usually varies every few days, and even then the tidal currents would be amply sufficient to take a vessel through without danger.

The amount of excavation required, allowing a slope at the sides of 1

in 10, would be but little over 250,000 cubic yards; and by either of the other channels proposed it would not be less than 400,000.

Dredges for this purpose should be furnished with bulwarks calculated to protect them from waves of at least five feet from the top of the crest to the bottom of the trough, and they should be able to work in a swell of at least 18 inches.

The summer season is the only one that can be depended upon for weather calm enough for even such a dredge to work continuously; during each of these months about 20 days are likely to be available; and in the months of May, September, and October, not more than half of that time can be counted upon with certainty.

I have no data at my command sufficient for determining the cost of the dredges, scows, and tug-boat which would be required to make the excavation, but should a dredge similar in construction to the one now used at Fort Taylor be considered appropriate, the following men would be required to work it, at the rates indicated below, viz: one engineer, $125 per month; one dipper tender, $3 per day; one fireman, $2 25 per day; four deck hands, $1 85 per day.

The cost of wood for fuel is usually about $7 per cord.

Should it be thought desirable that a channel of less depth than 18 feet be excavated, the following table will be of assistance in computing the cost of such:

For channel of 18 feet, 262,800 cubic yards of excavation required.
For channel of 17 feet, 184,800 cubic yards of excavation required.
For channel of 16 feet, 112,400 cubic yards of excavation required.
For channel of 15 feet, 55,000 cubic yards of excavation required.

The soundings on the chart are taken from mean low water. The average rise and fall of tides is two feet five inches, but the spring tides often rise as high as four feet above the plane of reference.

I am, general, very respectfully, your obedient servant,

WM. R. LIVERMORE,
1st Lieutenant Corps Engineers U. S. A.

Brevet Brig. Gen. J. H. SIMPSON,
Colonel Corps Engineers U. S. A., Key West, Fla.

Official copy:

J. H. SIMPSON,
Colonel Engineers and Brevet Brigadier General U. S. A.

NEW YORK, 45 DUANE STREET, *May* 16, 1868.

DEAR SIR: Yours was duly received, inquiring cost, capacity, &c., of one of our patent dredging machines.

We have a dredge (No. 2) now working in the Cunard dock, Jersey City, which will excavate in 25 feet water 2,000 cubic yards of stiff mud per day of 10 hours; in sand it would probably not excavate more than half the above amount; in coarse sand it will do more than in fine sand.

Will furnish a dredge similar to the above, with two scows of 200 yards capacity each, with right to use the same, for the sum of fifty thousand dollars, ($50,000.) Size of dredge-boat 80 by 30 and seven feet deep; capacity of bucket, five cubic yards; consumes from one and a half to two tons of coal in 10 hours, and requires about seven men to work her. The cost of a good tug-boat, (not new,) $10,000.

We can furnish a good dredge of about 25 horse-power, with two 200 yards scows, for $35,000, capable of excavating in stiff mud from 1,000 to 1,200 cubic yards in 10 hours. Size of dredge on deck 28 by 70; six feet between decks; would consume three-fourths to one ton anthracite coal in ten hours, and requires five or six hands to work it. Size of scows 85 by 23, seven and a half deep; capacity of bucket one and a half yard.

Very respectfully, yours,

MORRIS & CUMINGS,
Per JAMES CUMINGS.

J. H. SIMPSON,
Brevet Brigadier General and Colonel Engineers U. S. A.

Official copy:

J. H. SIMPSON,
Colonel Engineers and Brevet Brigadier General U. S. A.

APPENDIX J.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, August 22, 1868.

SIR: I have the honor to submit the following annual report for the fiscal year ending June 30, 1868, on the survey of a ship canal around the falls of the Ohio:

Operations were commenced by me on this survey in July, 1867. On the 8th of February last I transmitted a special report as directed from headquarters corps of engineers. In this special report I detailed all of my operations up to that date, and the result of those operations.

From that date to the end of the fiscal year I have been engaged in studying and arranging the details, preparing the specifications, and making the drawings of the work I proposed should be done. The drawings I have transmitted to the department this day by express.

I found in the course of my studies on these details that probably a strong crib-dam would be better than a masonry dam across the crest of the rocks in front of Louisville, to raise the low-water mark three feet, and have accordingly made the change. The details of this proposed dam are shown on the drawings.

I also found after I had made my special report that an error had been made in copying the levels, and that the lift of the dam proposed by me to be built across the head of Falling Run pool is $11\frac{2}{100}$ feet if a canal is built on the Indiana side, and $5\frac{73}{100}$ if only the Louisville and Portland canal extension is completed.

A lock with a corresponding lift will therefore be necessary in the dam to pass boats during low stages of the river. The drawings represent the details of this dam with a lock arranged under the supposition that the canal on the Indiana side along the route proposed by me will be built. In case it is decided that no canal will be built on the Indiana side, this dam and lock, of course, will be considerably cheaper, as then they will require a lift of only $5\frac{73}{100}$ feet.

The total cost of the upper dam, according to the revised plan, is estimated at $40,000, as shown in detail in annexed estimate. The total cost of the lower lock and dam arranged for the canal on the Indiana side is estimated at $375,000, as shown in details annexed; and the total cost of the same dam arranged only for the Louisville and Portland canal extension is estimated at $270,000. These estimates are, however, only approximate. New levels must be taken and these dams carefully located before any exact estimate can be made.

The total cost then of completing the work recommended by me would be as follows:

For Louisville and Portland canal extension	$933,500 00
For new canal Indiana side	3,470,000 00
For two dams and one lock	415,000 00
Total	4,818,500 00

If no new canal is built on the Indiana side the total would be as follows:

For Louisville and Portland canal extension	$933,500 00
For two dams and one lock	310,000 00
Total	1,243,500 00

The secretary of the Louisville and Portland Canal Company estimates that on the 30th of June, 1869, there will probably be $180,000 in the hands of the treasurer of the company, and $85,000 have been appropriated for the fiscal year ending June 30, 1869.

In case that only the Louisville and Portland canal extension is completed, there would remain $978,500 to be appropriated to complete the work, and this amount could be profitably expended during the fiscal year ending June 30, 1870.

This does not include the $1,570,000 in bonds, having several years to run, the payment of which the government must assume in order to obtain possession of the Louisville and Portland canal.

In case a canal is also built on the Indiana side, on the route recommended by me, $3,575,000 would be required in addition to the above mentioned sum to complete the work, and $1,000,000 additional could be profitably expended during the fiscal year ending June 30, 1870. The work is situated in the second collection district of Indiana, and the third collection district of Kentucky.

The nearest port of entry is Louisville, Kentucky. The amount of revenue collected during the fiscal year ending June 30, 1868, was $201,350 48.

The commerce and navigation of the Mississippi and all its tributaries would be benefited by the completion of this work. It has been estimated that 8,000,000 of tons were transported on these rivers during the year 1866, and it is stated that the amount increases annually.

The amount of cash received and expended on account of the survey for this work during the fiscal year ending June 30, 1868, is herewith transmitted.

I am, sir, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers, Brevet Major General U. S. A.

Brig. Gen. and Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers, Headquarters Corps of Engineers,
Washington, D. C.

CANAL AROUND THE FALLS OF THE OHIO.

Estimate of cost of a rectangular crib-dam on crest of the falls of the Ohio river.

Cribs, 6 feet wide; length of dam, 45,000 feet; cross-ties, 6 feet long, and 10 by 12 inches; stringers, in length, 21 feet and upwards; stringers

next rock, 10 by 15 inches; stringers in cribs, 10 by 12 inches; 2,000 feet lineal foundation, 1 foot above low water; 2,200 feet lineal foundation, 1 foot below low water; 300 feet lineal foundation, 2½ feet below low water.

ESTIMATE.

450 cross ties above low water, board measure, 27,000 feet, at $25 per M	$675 00
250 cross-ties below low water, board measure, 15,000 feet, at $25 per M	375 00
Stringers above low water, 13,000, board measure; stringers below low water, 5,000, board measure; 18,000 feet, at $25 per M	4,500 00
Stringers next rock foundation, board measure, 11,000 feet, at $25 per M	2,750 00
Roofing plank, 4 inches thick, 6 feet long, board measure, 108,000 feet, at $30 per M	3,240 00
Sheeting at upper side dam, double course, 3 inches thick, board measure, 120,000 feet, at $30 per M	3,600 00
Planking on lower side dam, 3 inches thick, board measure, 23,000 feet, at $30 per M	690 00
1,800 wrought-iron bolts, 10 inches square, 24 inches long, 11,700 pounds, at 10 cents per pound	1,170 00
400 wrought-iron bolts, 1¼ inch square, 30 inches long, 5,200 pounds, at 10 cents per pound	520 00
440 wrought-iron bolts, 1¼ inch square, 72 inches long, 14,000 pounds, at 10 cents per pound	1,400 00
60 wrought iron bolts, 1¼ inch square, 90 inches long, 3,300 pounds, at 10 cents per pound	330 00
40,000 spikes, ⅝ inch square, 6 inches long, 1,200 pounds, at 10 cents per pound	1,200 00
1,800 spikes, ⅝ inch square, 10 inches long, 19,700 pounds, at 10 cents per pound	1,970 00
Stone filling, 3,100 cubic yards, at $1 per yard	3,100 00
Graveling 2,000 cubic yards, at 50 cents per yard	1,000 00
Abutment masonry, 50 cubic yards, at $13 per yard	650 00
Coffer-dam and leveling off	10,000 00
Drilling holes in rock, 1,000, at $1 per M	1,000 00
Contingent, &c	1,830 00
Total estimates	40,000 00

Respectfully submitted.

G. WEITZEL,
Major of Engineers, Brevet Major General U. S. A.

Estimated cost of lock and dam opposite New Albany, Indiana, 11.02 high, and of the construction shown on the drawings, at the prices mentioned in appendix.

DAM.

Cribs of dam	$94,037 00
Pier masonry	14,300 00
Abutment masonry	9,100 00

Graveling	$4,000 00
Excavation	350 00
Coffer-dam	10,000 00
Dredging	1,000 00
Contingencies, &c	17,213 00
Total estimated cost of dam	150,000 00

LOCK.

Earth excavation in lock pit, 5,000 cubic yards, at 35 cents per yard	$1,750 00
Slate excavation in lock pit, 5,000 cubic yards, at $1 50 per yard	7,500 00
Coffer-dam	10,000 00
Concrete, 3,000 cubic yards, at $6 50 per yard	19,500 00
Lock masonry, 11,000 cubic yards, at $13 per yard	143,000 00
Lock gates and machinery, two pairs, at $12,000 per pair	24,000 00
Contingencies, &c	19,250 00
Total estimated cost of lock	225,000 00

Estimated cost of dam as above	$150,000 00
Estimated cost of lock as above	225,000 00
Total estimated cost of lock and dam	375,000 00

Respectfully submitted.

G. WEITZEL,
Major of Engineers, Brevet Major General U. S. A.

Estimated cost of dam opposite New Albany, Indiana.

Length, 1,700 feet; width, 18 feet; height above low-water, 5.73 feet; depth of water, 10 feet; slopes of upper roof, 1½ to 1; slopes of lower roof, 1½ to 1; cross-ties, 8 feet, centre to centre; cross-ties and stringers, 10 by 12 inches; ridge timber, 12 by 15 inches.

ESTIMATES.

Cross-ties, 275,600 feet, board measure, at $25 per M	$6,890 00
Stringers, 391,000 feet, board measure, at $25 per M	9,775 00
Sheeting at upper side dam, one course, 3 inches; one course, 2 inches; 85,000 feet, board measure, at $30 per M	2,550 00
Roofing, (lower,) 6 inches, 122,400 feet, board measure, at $30 per M	3,672 00
Roofing, (upper,) 6 inches, 110,500 feet, board measure, at $30 per M	3,315 00
Roofing, (upper,) 4 inches, 40,800 feet, board measure, at $30 per M	1,224 00
Wrought-iron bolts, 1 inch square, 21 inches long, 55,900 pounds, at 10 cents per pound	5,590 00
Spikes, ⅜ inch square, 12 inches long, 8,100 pounds, at 10 cents per pound	810 00

Spikes, ½ inch square, 14 inches long, 13,000 pounds, at 10 cents per pound	$1,300 00
Spikes, ¼ inch square, 6 inches long, 1,700 pounds, at 10 cents per pound	170 00
Stone filling, 12,000 cubic yards, at $1 per yard	12,000 00
Graveling, 6,000 cubic yards, at 50 cents per yard	3,000 00
Abutment masonry, 200 cubic yards, at $13 per yard	2,600 00
Abutment, excavation, and dredging foundation for dam, 3,000 cubic yards, at 20 cents per yard	600 00
Coffer-dam	5,000 00
Contingencies	6,504 00
	75,000 00

Estimated cost of lock, 100 by 400 feet, to be built in connection with the above dam.

Excavation of earth in lock pit, 5,000 cubic yards, at 35 cents per yard	$1,750 00
Excavation of slate in lock pit, 5,000 cubic yards, at $1 50 per yard	7,500 00
Coffer-dam	10,000 00
Concrete, 3,000 cubic yards, at $6 50 per yard	19,000 00
Lock masonry, 9,000 cubic yards, at $13 per yard	117,000 00
Lock gates, 2 pairs, at $10,000	20,000 00
Contingencies	19,250 00
Total estimated cost of lock	195,000 00
Total estimated cost of dam	75,000 00
Total estimated cost of dam and lock	270,000 00

Respectfully submitted.

G. WEITZEL,
Major of Engineers, Brevet Major General U. S. A.

Statement showing total cost of the survey of a ship canal around the falls of the Ohio river, for the fiscal year ending June 30, 1868, under the direction of Brevet Major General G. Weitzel, major of engineers.

Hired men	$13,162 00
Commutation, quarters and fuel	975 57
Office furniture and stationery	715 93
Mileage	90 80
Transportation of instruments	10 40
Postage	16 35
June 30, 1868, total cost	14,971 05
Deduct revenue tax from salaries	245 43
June 30, 1868; amount expended during the year	13,725 62
June 30, 1868; balance on hand	274 38
	14,000 00

June 30, 1868, received during the year $14,000 00

Respectfully submitted.

G. WEITZEL,
Major of Engineers, Brevet Major General U. S. A.

J 1.

NEW ALBANY, INDIANA,
February 8, 1868.

GENERAL: I was charged by you with the execution of the work ordered in the following joint resolution of Congress:

PUBLIC RESOLUTION No. 20.

JOINT RESOLUTION providing for the necessary surveys for a ship canal around the falls of the Ohio river, for military, naval and commercial purposes.

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized and directed to cause surveys, with plans and estimates of cost, to be made by an officer of engineers, for a ship canal around the falls of the Ohio river, on the Indiana side thereof, of suitable location and dimensions for military, naval and commercial purposes, and also to cause said officer to estimate the expense of completing the Louisville and Portland canal, on the Kentucky side of said falls, according to the plan on which the said canal company is now progressing with said work, and that the expenses of both be defrayed from the sums appropriated in the acts of June 23, 1866, and March 2, 1867, for examinations and surveys relating to the improvement of harbors and rivers on the northwestern lakes.

Approved March 29, 1867.

I was furnished by you with a copy of the report of Captain (now Colonel) T. J. Cram, corps of engineers, on the best mode of improving the navigation of the Ohio river at the falls at Louisville, made in 1844; a copy of a report of a board of engineers in reference to the improvement of the falls of the Ohio, at Louisville, made in 1853; and a set of drawings made under the directions of Colonel S. H. Long, topographical engineers, in the year 1849, and bearing on the same subject. These were furnished me with the understanding that the information contained in them should not supersede the surveys required by the joint resolution, but that they were merely placed at my disposal for such aid as could be derived from them in the way of facilitating my surveys and examinations.

Accordingly I organized my party at this place and commenced operations in July, 1867. In the absence of any more definite or detailed instructions than the joint resolution contained, I believed it my duty, in view of the fact that the government had twice before been under the expense of this survey, to make this one so minute and so much in detail that every possible route on the Indiana side that can be suggested and be calculated from the notes which we would gather, and thus save any further expenditure of money on this account. My operations were conducted with this view.

The general map which accompanies this report shows the topography of the Indiana shore, within the practical limits for canal purposes, in considerable detail.

Many of the most important points of the horizontals drawn on this map were accurately determined, and the intermediate portions sketched

in. They are accurate enough for all practical purposes. The references are written on all of them, the plane of reference being a horizontal plane six feet lower than the upper surface of the lower miter sill of the old locks of the Louisville and Portland canal.

We had a remarkably favorable season for our work. We first surveyed the Indiana side; then, when the water reached its lowest stage, we took the river bed; then the Louisville and Portland canal and vicinity; and finally located and carefully went over nine different lines on the Indiana side. These nine lines, by their combinations, giving fourteen routes for a canal.

While these operations were in progress I collected all the information I could for the purpose of enabling me to determine the proper dimensions for a canal which would be suitable for commercial purposes.

I assumed that a canal with such dimensions would at the same time be suitable for military and naval purposes. I found two different opinions on this subject; some believing that locks the size of the new locks on the Louisville and Portland canal extension, which are 350 feet long and 80 feet wide, would be large enough, because in the future no more boats larger than these dimensions will be built, and that the bulk of the carrying trade on this river would be done by barges drawn by tow-boats.

Many of the practical steamboat men, however, with whom I conversed on this subject are of the opinion that the locks of a new canal should be much larger, contending that the future of the carrying trade would be either by boats built very wide, so as to carry a heavy load with light draught of water, or in fleets of barges drawn by tow-boats, so that in either case the locks must be large to accommodate the large boat, or to take in at a time the whole tow and thus save the time and expense of breaking up a tow to get through the canal and putting it together again below. Besides, they say that the size of the locks on this canal generally fixes the size of the boats, and that if the locks were larger, the boats would be built larger, because, up to a certain limit, a large boat can make a trip in shorter time with a larger load than a smaller boat, and with equal expenditure of fuel.

There are at least two boats now running on this river that could not be passed through the new locks of the Louisville and Portland canal extension. About the middle of last October a convention of steamboat owners and masters assembled at Cincinnati, Ohio. This convention was composed of delegates from the principal points of the west, all of whom had either spent most of their lives or invested a great deal of capital in steamboats, or both. I therefore addressed a letter to the chairman of this convention, asking him to get a vote on the question of proper dimensions for the locks of a new canal, and he did so. The convention fixed upon the locks for a new canal to be 400 feet long and 110 feet wide, but recommended the immediate completion of the Louisville and Portland canal in accordance with the present plan, which is with locks as above stated, 350 feet long and 80 feet wide, the canal being 90 feet wide, and having six feet of water over the miter sill of the guard gate at the lowest stage of water.

I think that the locks of the new canal should be at least 100 feet wide and 400 feet long. The canal itself should be 120 feet wide and should have six feet of water over the miter-sill of the guard gate at the lowest stage. But in order to show the matter more fully I present herewith estimates for each route on the Indiana side with these dimensions, and also with the exact dimensions of the proposed Louisville and

Portland canal extension. A proper descent has been calculated for in both cases:

INDIANA SIDE.

Route No.	Descent of bottom.	Cost.		Length.	Number of bridges required.	Lockage.
		90 feet wide.	120 feet wide.			
	Feet.			*Miles.*		*Feet.*
1	4½	$12,025,000	$14,600,000	8 4/5	13	30
2	4½	11,060,000	13,475,000	8 3/5	16	30
3	4½	11,025,000	13,500,000	8 3/5	17	30
4	4½	10,430,000	12,675,000	7 4/5	13	30
5	4½	10,140,000	12,300,000	8 4/5	12	30
6	4½	6,340,000	7,835,000	5 2/5	9	28
7	4½	5,710,000	6,852,000	4 1/5	5	28
8	4½	5,385,000	6,475,000	4 1/5	4	28
9	3½	4,160,000	5,105,000	3 1/5	6	24
10	3	3,560,000	4,280,000	2 4/5	2	24
11	3	3,255,000	3,910,000	2 3/5	2	24
12	3	3,835,000	4,725,000	2 4/5	6	20
13	3	3,275,000	3,920,000	2 2/5	3	20
14	3	2,970,000	3,550,000	2 1/5	2	20

The lockage on each of these routes is to be effected by means of two lift locks.

There should be six feet of water over the miter sill of the guard gate, because when there is 10½ feet of water on the upper bars of the Ohio river, there would be about 11 feet over the miter sill of such a canal. A boat loaded then to draw 10½ feet and just scrape over the bars would have six inches to spare in crossing the miter sill, which I think is little enough. The bottom of the canal should have a descent so as to enable the water to assist in clearing out any sediment that may be brought into the canal when in use, to allow for the descent in the upper surface of the water in the canal when it is drawn off for lockage, and to make certain, if a boat gets over the miter sill, that it will get through the canal without rubbing. The depth of water on the lower miter sill of the lock to be six feet at low water. The river bank of the canal and the guard gate to rise to a horizontal plane, four feet higher than the highest known flood, that of 1832. The highest stage of water in which the canal will be used is assumed at 10 feet above low water at the head of the falls. The top of the side walls of the canal should be in a horizontal plane, five feet higher than the assumed height of the highest stage in which the canal will be used.

At the level of the top of the side walls on the river bank there should be a berm 20 feet wide. Above this level, for 15 feet in height, the inside of the banks of the canal shall have a slope of one and a half foot base to one foot rise; then there shall beran other bem 20 feet wide, and then to the top of the bank it shall slope again one and a half foot base to one foot rise. The top of the bank shall be 20 feet or more in width, according to circumstances.

Where the canal crosses a creek or depression, the inside bank of the canal shall be as high as the side wall, 20 feet wide at top, and the reverse slope shall be the natural slope of the earth. Where it passes through a cutting, the form of the inside, up to the natural surface, shall be the same as the river bank. All bridges over the canal shall be furnished with draws of suitable construction. The side wall of the

lower lock at its lower end to be raised to the height of the banks of the canal, and to be provided with a guard gate to prevent the water in high stages, when the canal is not in use, from backing into the locks and annually leaving deposits of mud, which would be expensive to remove. This guard gate at the lower lock to be made in two sections, on account of its great height. Suitable passing places shall be provided, the number depending on the length of the route.

With reference to the table above given, it should be said that routes Nos. 12, 13, and 14 come out at the big eddy. This is such a troublesome place for an entrance or outlet to a canal, on account of the whirlpools which exist there, that I consider all these routes should be at once rejected, especially, too, as they do not come out below but on the falls.

It will be seen that all of the others are larger than the Louisville and Portland canal, many of these enormously expensive; all require heavy rock excavations, and all of them cross either one or all of the five streams which exist on the Indiana side, and which, not being needed as feeders, are a grievous obstruction. The route which approaches nearest in feasibility to the Louisville and Portland canal is route No. 11.

The history of the Louisville and Portland canal is so correctly and thoroughly given in a report which probably is now before Congress, made last summer under the direction of the honorable Secretary of the Treasury, by Mr. W. D. Gallagher, that only a synopsis is thought necessary here by way of explanation.

The Louisville and Portland canal was completed in December, 1830, by a company chartered by the State of Kentucky. The government was a stockholder to the amount of 2,335 shares, costing $233,500.

In 1831 the government received 567 shares more in lieu of dividends. Between 1831 and 1842 it received $257,778 in cash from the dividends declared by the company; so that at the end of 12 years the government received $24,278 in cash and 567 shares in stock more than it invested in the canal, and was still the owner of 2,902 shares in the canal, valued at $290,200; thus receiving $547,978 for its original investment in the canal.

From 1842 up to date no dividends have been declared, the net income of the canal up to 1859 being devoted to the purchase of stock owned by private individuals, (said stock being held in trust by the board of directors,) and since 1859 to the enlargement and extension of the canal, and to create a sinking fund for paying the bonds which were issued by the company to defray the expenses of said work.

In 1860 this enlargement and extension was begun on plans submitted by Mr. T. R. Scowden, a civil engineer of experience and reputation, and stopped in 1866 for want of funds, after $1,825,403 23 had been expended for lands and work on the improvement; thus making the cost of the canal, as it now stands, $2,825,403 23. If there had been no war this sum would have been sufficient to have completed the work according to the original plan.

To report how much more money it will now require to finish it is one of the duties assigned me by the joint resolution. The old canal is 64 feet wide in the clear and one and nine-tenths miles long. The lockage is effected by three (now dilapidated) lift-locks of about eight and two-thirds feet lift each, and 200 feet long by 50 feet wide in the clear. The proposed improvement intended to increase the old canal to 100 feet in width, to be lined on both sides with a vertical dry wall 17 feet high. The embankment to be formed on both sides of the canal by setting off a berm 15 feet wide, then carrying up a slope one and a half foot horizontal to one foot perpendicular, 15¾ feet high, to a second berm 15 feet wide; then carrying up a second slope of the same form and height as the

first, which will reach the summit of the embankment about 49½ feet above the bottom of the canal, and will be two feet higher than the highest known flood.

The depth of water in the canal at the lowest stage of the river to be six feet. To have a guard gate at the head of the canal with suitable abutments, both built as high as the canal embankment. To have three passing places, including a spacious basin formed by taking in the present dry dock. To have a crib dam on the river side from the head of the canal to protect boats in passing in and out of the canal from accident or delay. To have a floating boom at the head of the canal to exclude ice and drift. To repair the old locks for passing small craft of all description. To diverge the branch canal at a point about 470 feet above the old guard-gate pier, extending about 2,600 feet westerly to the new locks located near the foot of Sandy island. To blast the rocks at the foot of the locks so as to open a wide and safe channel for going in and out of the canal. To effect the lockage by two lift-locks about 13 feet lift each, and 350 feet long and 80 feet wide. The bottom of the canal to be level. During the progress of the work, as the price of labor and materials rose on account of the war, the directors, with a laudable desire to build at least a "working" canal with the means at their disposal, compelled the engineer to make several changes in his plans, the most important of which was reducing the width of the canal to 90 feet. This, for that width of locks, was a good change.

To complete the work according to the modified plan will cost $1,178,000. To complete it according to the original plan will cost $1,294,000, and to complete, as I think it should be, with the river bank raised to a plane four feet higher than the highest known flood, and a fall of one foot per mile, will cost $1,394,000.

In order to understand positively on what terms the government could get the ownership of this canal, I addressed a letter on the 13th of December, 1867, to the president of the company, the Hon. James Guthrie, to which I received the following reply:

OFFICE OF THE LOUISVILLE AND PORTLAND CANAL COMPANY,
December 14, 1867.

The following reply to the letter of General Weitzel was made and ordered to be placed on the minutes:

G. WEITZEL, *Major of Engineers, Brevet Major General U. S. A.*

DEAR SIR: In reply to your letter of 13th instant, the president and directors of the Louisville and Portland Canal Company have to say that they consider themselves as trustees of the stockholders of the company, the objects of the trust being to cause said canal to be so enlarged and improved as to make it sufficient for the requirements of the commerce of the Ohio river, and finally to make it a free canal; and that, having no personal objects to subserve, they would willingly surrender to the government of the United States all the rights, titles, privileges, assets, &c., of the company, provided the government shall purchase the five shares of stock which they hold, and assume the indebtedness of the company incurred in the prosecution of the canal enlargement, and also assume the duties of the trust, which they hold to be the completion of said work of enlargement as contemplated.

The bonded indebtedness of the company is as follows:

370 bonds due in 1871	$370,000
399 bonds due in 1876	399,000
398 bonds due in 1881	398,000
400 bonds due in 1886	400,000
	1,567,000

The five shares of stock are $100 each.

There is on hand to the credit of the sinking fund a balance of $217,453 70.

For a detailed statement of the affairs of the company we submit a bound copy of the annual reports of the company from the year 1826 to June 30, 1867.

Very respectfully,

JAMES GUTHRIE, *President.*

J. H. ROHER, *Secretary.*

Thus it will be seen that if the government will make this canal free by buying the remaining five shares of stock, and assuming a debt which is payable in equal instalments in 3, 8, 13 and 18, of $1,567,000, it will become the owner of a necessary piece of property which cost $2,825,403 23, and all of which sum, considering the cheapness of labor and material when the original canal was built, it is now worth. It will get besides about $220,000 or more in cash, after the five shares are bought in, to begin the work on completing the extension. The amount of cash in the hands of the treasurer on December 16, 1867, was $217,453 70; and it is not probable that this sum will be diminished, but rather increased.

The amount, in addition to the cash the company has on hand, then required to be appropriated to make this a complete and perfect canal, would be $1,174,000 and $1,567,000 in bonds bearing a six per cent. currency interest, a less rate than any public security at the present time bears. The total sum, therefore, required is $2,741,000, a great part of which is payable only in several years to come.

All the foregoing is written on the assumption that the canal built by the government should last at least a hundred years, and in making the estimates only the very best class of materials was considered, and that during this period the Ohio river would never be improved. But early in my studies on this subject I came to the belief that this river, even if not immediately, will be improved; and this belief has grown so strong on me as now to amount to almost a positive conviction. When one reads the accounts and descriptions of internal improvements in the countries of Europe and finds streams improved by the state and with benefits to the state, in comparison to which an average branch of the Ohio river is quite a river; and when one sees that a distinguished foreign engineer lays it down as a principle that a stream 19½ feet wide and 1½ feet deep is a navigable stream and worthy of fostering care, and all this in addition to railroads, one is naturally led to think over the wants of this country in the future, even if the past had not and the present did not imperatively demand such an improvement. But the past has and the present does demand it. This river, with its branches, drains the whole of parts of ten States of the Union, among them the wealthiest and most populous. It is one of the most important in a system giving 18,000 miles of navigable rivers.

The States lying upon the banks of the Ohio and Mississippi rivers, 14 in number, had, by the census of 1860, a population of 16,909,494, or more than half the whole population of the United States; and these two rivers have a coast line of 36,098 miles, while the coast of the Atlantic is 2,163 miles, and the Gulf of Mexico 1,764 miles, and of the Pacific 1,343 miles, on a line of 21,354 miles, including bays and indentations.

These rivers drain an area of 1,785,267 square miles, more than half of the whole 3,001,002 square miles in the United States, and these 14 States, in 1860, contained 94,402,869 of the 163,110,720 improved acres, and 126,703,393 of the 244,101,818 unimproved acres of the whole United States; and the valuation of property in these 14 States shows, $8,467,511,274 of the whole valuation of the United States, $16,077,358,715 showing very conclusively that these 14 States pay more than one-half the taxes, work more than half of the improved land, have the majority of the population and also the majority of the land to develop, of the whole United States. By the census of 1860, the whole product of the United States was valued at $1,900,000,000, while the foreign exports of the domestic products were only $373,189,274, or less than one-fifth of the whole product, leaving four-fifths for exchange in domestic commerce between the States.

The proportion of the whole product afforded by these 14 States we

speak for may be judged by these returns of their produce, gathered from the census of 1860, and compared with the whole United States, as follows:

	The fourteen States.	The whole United States.
Corn ..... bushels..	632,454,375	838,792,740
Wheat ..... bushels..	126,930,730	173,104,924
Oats ..... bushels..	103,995,461	172,643,185
Tobacco ..... pounds..	345,400,759	434,209,461
Sugar ..... pounds..	222,636,000	230,982,000
Cotton ..... pounds..	1,079,799,600	2,154,820,800
Wool ..... pounds..	31,277,839	60,264,913
Hay ..... tons..	9,297,743	19,083,896
Butter ..... pounds..	239,601,405	459,681,372
Hemp ..... tons..	69,470	74,493
Hogs	22,225,766	33,512,867
Bituminous coal ..... bushels..	3,247,264,425	3,621,923,165
Horses and asses	4,804,634	7,409,322
Cattle	12,517,392	25,616,019
Sheep	11,973,315	22,471,275

Showing for the river States a great preponderance in the products of the whole country.

The total tonage owned in the United States is returned in the census of 1860 as 5,353,868 tons, and the portion belonging to the 14 States as 996,266 tons, but it is estimated by competent parties that the steamers on the Ohio and Mississippi have carried 7,905,216 tons during the year 1866, evincing the activity in domestic commerce of these river States, and this commerce but yet in its infancy, for it is developing daily, and demonstrating that from these States has and must come the food supply for the whole nation and for exports; and that they must also supply the gold and silver States which are developing so largely and quickly upon the tributaries of their rivers.

Besides, on an improved Ohio river, more freight would be carried and at cheaper rates between Pittsburg and Cairo than by a half dozen railroads connecting these points.

If these statistics are not sufficient, I will add that it too often happens, as it did last fall, that the people along the greater part of these rivers have to pay 50 cents or more a bushel for coal, when with an improved river it would only be worth 16 cents. That many thousands suffer cold and many are thrown out of employment by manufacturers stopping for want or the high price of coal, and that many thousand men engaged in the river trade are annually thrown out of employment for several months because this river is not improved. I am confident that the amount of money annually lost in this way to the people along these rivers would pay the interest on the sum required to do the work, and have so large a surplus for a sinking fund as in a few years would eliminate the whole amount.

But this subject is in the hands of an engineer of the greatest ability, and my desire was not to encroach on his duties, but merely to sketch some of the points which forced the conviction upon me that in considering plans for a canal around the falls of the Ohio we must take into consideration that the river will be improved during the life of the canal, and the more so as there will be a large saving of money by it, especially if a new canal is built on the Indiana side.

In order to understand what I propose, it must be known that the mass of rocks causing the falls of the Ohio is a natural dam in the river, and forms a pool which extends up to Grassy Flat shoals, 16 miles above;

that below the falls, in extreme low water, the Albany and Portland bars are insurmountable obstructions; that between Sandy island; and the Indiana shore the river bed in that stage is in places nearly dry, and that just in front of the lower portion of the city of New Albany there begins another deep pool, into which the Falling Run creek enters.

Now my proposition is that a strong masonry dam be built across the crest of the rocks in front of Louisville, to raise the low-water mark three feet, and another strong crib-dam be built across the head of Falling Run pool, to raise the low-water mark between it and the foot of the falls so much that at no stage will there be less than six feet of water between them. Both of these dams shall be provided with suitable sluices. The lower one to have a sluice-way next to the Indiana shore, 200 feet wide, in which the water shall be confined by a return of the crib-dam, parallel to the Indiana shore. This return shall be 1,200 feet long, as the fall produced by this dam in extreme low stages would be about four feet. Up this sluice-way boats could warp in extreme low stages. A lock of four feet lift might be substituted if necessary, in the future, when a system of river improvement has been devised and put into execution.

The upper dam improves Grassy Flat shoals, one of the worst obstructions in low water between Louisville and Cincinnati. The lower improves the river up to Big Eddy. Neither will raise the high-water mark more than two inches. Both together reduce the fall at extreme low stages to 25 feet; thus diminishing the lift of the locks by one foot. The upper one can under no circumstances cost more than $50,000, nor the lower one cost more than $175,000, taking the most unfavorable view in both cases. The upper one saves three feet of solid rock excavation along the whole line of any canal which can be built. This item in the Louisville and Portland canal extension amounts to $270,500. The lower saves in the same work all the channel rock excavation below the locks, amounting to $190,000. Deducting the cost of these two dams from the amount they save, we have a clear gain of $235,500 on this route alone. On the Indiana side the gain will be much greater, because there they make a route which comes out just below the falls, as suitable as the longest one coming out at Falling run. The lower one, besides, gives an unobstructed ferry communication all the year round between New Albany and Portland, and thus to Louisville, which is a great benefit to the intercourse between those places.

To show the gain in each route I give the following table:

Route	Cost without the dams.	Cost with dams.	Saving.
Louisville and Portland canal on plan last adopted	$1,178,000	$657,300	$235,500
Louisville and Portland canal according to original plan	1,295,000	834,500	235,500
Louisville and Portland canal as I think it should be	1,394,000	933,500	235,500
Indiana side, No. 1, 90 feet wide	12,025,000	11,210,000	590,000
Indiana side, No. 1, 120 feet wide	14,600,000	13,475,000	900,000
Indiana side, No. 2, 90 feet wide	11,060,000	10,285,000	550,000
Indiana side, No. 2, 120 feet wide	13,475,000	12,400,000	850,000
Indiana side, No. 3, 90 feet wide	11,025,000	10,075,000	725,000
Indiana side, No. 3, 120 feet wide	13,500,000	12,380,000	895,000
Indiana side, No. 4, 90 feet wide	10,430,000	9,610,000	495,000
Indiana side, No. 4, 120 feet wide	12,675,000	11,675,000	775,000
Indiana side, No. 5, 90 feet wide	10,140,000	9,425,000	490,000
Indiana side, No. 5, 120 feet wide	12,300,000	11,300,000	775,000
Indiana side, No. 6, 90 feet wide	6,340,000	5,810,000	305,000
Indiana side, No. 6, 120 feet wide	7,835,000	6,960,000	650,000

Table showing the gain in each route—Continued.

Route.	Cost without the dams.	Cost with dams.	Saving.
Indiana side, No. 7, 90 feet wide	$5,710,000	$5,230,000	$255,000
Indiana side, No. 7, 120 feet wide	6,852,000	6,210,000	417,000
Indiana side, No. 8, 90 feet wide	5,385,000	4,925,000	235,000
Indiana side, No. 8, 120 feet wide	6,475,000	3,815,000	435,000
Indiana side, No. 9, 90 feet wide	4,160,000	3,770,000	165,000
Indiana side, No. 9, 120 feet wide	5,105,000	4,550,000	330,000
Indiana side, No. 10, 90 feet wide	3,560,000	3,230,000	105,000
Indiana side, No. 10, 120 feet wide	4,280,000	3,835,000	220,000
Indiana side, No. 11, 90 feet wide	3,255,000	2,945,000	85,000
Indiana side, No. 11, 120 feet wide	3,910,000	3,470,000	215,000
Indiana side, No. 12, 90 feet wide	3,835,000	3,505,000	105,000
Indiana side, No. 12, 120 feet wide	4,725,000	4,350,000	150,000
Indiana side, No. 13, 90 feet wide	3,275,000	2,995,000	550,000
Indiana side, No. 13, 120 feet wide	3,920,000	3,540,000	155,000
Indiana side, No. 14, 90 feet wide	2,970,000	2,700,000	45,000
Indiana side, No. 14, 120 feet wide	3,550,000	3,175,000	150,000

Thus showing a great saving, even if the cost of the dams is deducted as above. But, in justice, this should not be done, as these dams improve 20 miles at least of the Ohio river, and their cost should be properly charged to the Ohio river improvement. Under this view of the case the above table reads as follows:

Route.	Cost without the dams.	Cost with dams.	Saving.
Louisville and Portland canal on plan last adopted	$1,178,000	$657,300	$460,500
Louisville and Portland canal according to original plan	1,295,000	834,500	460,500
Louisville and Portland canal as I think it should be	1,394,000	933,500	460,500
Indiana side, No. 1, 90 feet wide	12,025,000	11,210,000	815,000
Indiana side, No. 1, 120 feet wide	14,600,000	13,475,000	1,125,000
Indiana side, No. 2, 90 feet wide	11,060,000	10,285,000	775,000
Indiana side, No. 2, 120 feet wide	13,475,000	12,400,000	1,075,000
Indiana side, No. 3, 90 feet wide	11,025,000	10,075,000	950,000
Indiana side, No. 3, 120 feet wide	13,500,000	12,380,000	1,120,000
Indiana side, No. 4, 90 feet wide	10,430,000	9,610,000	720,000
Indiana side, No. 4, 120 feet wide	12,675,000	11,675,000	1,000,000
Indiana side, No. 5, 90 feet wide	10,140,000	9,425,000	715,000
Indiana side, No. 5, 120 feet wide	12,300,000	11,300,000	1,000,000
Indiana side, No. 6 90 feet wide	6,340,000	5,810,000	530,000
Indiana side, No. 6, 120 feet wide	7,835,000	6,960,000	875,000
Indiana side, No. 7, 90 feet wide	5,710,000	5,230,000	480,000
Indiana side, No. 7, 120 feet wide	6,852,000	6,210,000	642,000
Indiana side, No. 8, 90 feet wide	5,383,000	4,925,000	460,000
Indiana side, No. 8, 120 feet wide	6,475,000	5,815,000	660,000
Indiana side, No. 9, 90 feet wide	4,160,000	3,770,000	390,000
Indiana side, No. 9, 120 feet wide	5,105,000	4,550,000	555,000
Indiana side, No. 10, 90 feet wide	3,560,000	3,230,000	330,000
Indiana side, No. 10, 120 feet wide	4,280,000	3,835,000	445,000
Indiana side, No. 11, 90 feet wide	3,255,000	2,945 000	310,000
Indiana side, No. 11, 120 feet wide	3,910,000	3,470,000	440,000
Indiana side, No. 12, 90 feet wide	3,835,000	3,505,000	330,000
Indiana side, No. 12, 120 feet wide	4,725,000	4,350,000	375,000
Indiana side, No. 13, 90 feet wide	3,275,000	2,995,000	280,000
Indiana side, No. 13, 120 feet wide	3,920,000	3,540,000	380,000
Indiana side, No. 14, 90 feet wide	2,970,000	2,700,000	270,000
Indiana side, No. 14, 120 feet wide	3,550,000	3,175,000	375,000

These dams built, route 11, costing $3,470,000, is the best route on the Indiana side. It is shorter and cheaper than any other that comes out below the falls.

It requires only one railroad draw-bridge, and one other for other purposes. It has only one creek to cross. It begins nearly opposite Louisville, and a boat using it passes all the towns and cities which cluster around the falls. It therefore does not disturb their commercial relations. It is estimated to be 120 feet wide, and, built as already described, have locks 100 by 400 feet.

The total sum then required to make these improvements in a proper, thorough, and therefore economical manner, will be—

For Louisville and Portland canal extension	$933,500 00
For new canal, Indiana side	3,470,000 00
For two dams	225,000 00
Total	4,628,500 00

Deducting cash in hands of treasurer of the Louisville and Portland Canal Company, would leave $4,408,500 to be appropriated within a few years, and the $1,570,000 in bonds, which, as already stated, have several years to run.

I recommend the building of the new canal on the route indicated on the Indiana side, in addition to the Louisville and Portland canal, because it is the only one on that side of the river that approximates in suitability to the Louisville and Portland in an engineering point of view. It has a better entrance, and will have a better outlet if the dams are built. At the same time it is much longer, requires more rock excavation, and has a small creek to cross. It requires one bridge less than the Louisville and Portland canal.

If this recommendation is approved by Congress, I will need the following appropriations for the fiscal year ending June 30, 1869:

For completing the Louisville and Portland canal extension	$933,500 00
For commencing the new canal on the Indiana side	1,000,000 00
For constructing the two dams above mentioned	225,000 00
Total	2,158,500 00

It would also require authority to build the dams when the season is favorable, and the money should be kept to the credit of the work, whether it is done the first or third year after the appropriation is made; for there may not be a very low stage of water again for two or three years, and a foot or two difference in the stage of the river would make quite a difference in their cost.

To show the necessity of an additional canal with such large locks, I will mention a case which occurred last month. The steamer Great Republic left New Orleans for Cincinnati with the enormous load of 1,900 tons. She crossed the falls of the Ohio with about 1,500 tons. While she was unloading at Cincinnati the river fell, and if she had not hurried and made a remarkably quick trip, and relinquished her engagements for freight, she would have been unable to have gotten back, and would have suffered a much greater loss than she did. Now, then, if the Louisville and Portland canal extension had been completed it would not have helped in this case, because the Great Republic is larger than the locks. But if the new canal had been built, there would have been no trouble at all.

But why not widen the Louisville and Portland canal, and build another set of locks, 100 by 400 feet, alongside of the others? Would it not cost less?

I answer to this, that it would cost less; but that there would be a great trouble from collision, danger of accidents, and loss of time in throwing all the work into this one channel when this work is done and made free, for then everything—steamboats, tow-boats and flatboats—will use the canal. The entrance to the Louisville and Portland canal is not very good, and its outlet is cramped by Sandy island; whereas on the Indiana side the entrance is good, and at the outlet there is a fine broad stream, where there is plenty of room.

The difference in cost should have no weight in comparison with these advantages, for even if it would cost a great deal more than this amount to improve these falls properly, the government is in honor bound to do it, I think, at once; and I do not think I state the case too strongly, for no one can deny that the Ohio river is a national highway, and that the falls at Louisville are an insurmountable obstruction in this highway, on an average, of 300 days in each year. It was clearly the duty of the government to remove this obstruction, as it did and does almost everywhere else on the Atlantic coast and northern lakes; but instead of doing this duty, it became a stockholder, and made money in a company chartered by the State of Kentucky, which levied an onerous and unjust tax on the commerce of the country. Up to June 24, 1867, there had been collected in cash from boats passing through this canal the enormous amount of $4,267,978 23, and when already 14 years ago only about one-half the boats navigating this river could pass through it. It has been reported to Congress from official sources, and is true, that many boats navigating this river have paid for tolls during their lifetime as much as one-third of their original cost. But this is not all. A great many boats that have been compelled to use this canal have been so much delayed and damaged in passing through it, in consequence of its incompleteness, that a large sum was lost or had to be immediately expended in repairs. It is a small estimate to say that the loss thus occasioned, with the tolls paid, would amount to $6,000,000. Add to this now for the extra expense, when boats could neither pass the falls nor through the canal, in transshipment of freight from Portland to Louisville, and *vice versa*, (and which reliable men inform me amounted, in the case of government freights, during the war, to a sum sufficient to have built an entirely new canal,) and it will be safe to say that the commercial interests of this country have been damaged to the amount of at least $15,000,000 by the failure of the government to construct a suitable canal at this place. And the attention of the government has been called to it almost annually, I understand, during the last 25 years, and certainly twice by government engineers of acknowledged ability and great experience and reputation. To make the matter worse, a bridge is building under a charter granted by the government, which, during the short period when formerly there was a good navigation on the falls, now interferes with it in the case of large boats, because in the very highest stages of the river there are some boats so large that, even by lowering their chimneys, they could not pass under the bridge. It should be stated, however, that these stages of the river do not last a long while; and yet the company, I am told, has done a great deal more than its charter requires; so that these canals should be at once built, because they will have to be used sometimes in high stages of the river now, as well as in low, and the canal will need a lock at its head instead of a guard-gate.

The only way for government to do to repair the wrong is to make this improvement, and, after it is made, only charge enough toll to pay for the management and for keeping it in repair. This is what the commercial and steamboat interests mean by a "free canal," and is all that they ask. The money thus appropriated will not be expended nor given to any particular section, but will be an investment which I am sure will pay to the government more interest in the end than any of its securities are now bringing, and will benefit the whole country. And I make this suggestion with a full appreciation of the fact that the country has a very large debt. I consider this improvement more deserving of support than any railroad enterprise. I do not wish to be understood, however, as wishing to disparage railroads, for I consider both equally necessary in their respective spheres for a proper development of the resources of the country. I desire here to state that if any system for the improvement of the Ohio river should be devised which would call for a dam on the crest of the falls higher than the one I have suggested above, it would give more than necessary depth of water in the Louisville and Portland canal; but in case of a new canal, every inch increase in the height of the dam would diminish, by quite a sum, the cost of excavation. I have taken the height above given for this dam, because it just gives enough water over the miter-sill of the Louisville and Portland canal, and does not perceptibly disturb the natural order of things.

In conclusion, I think that the directors of the Louisville and Portland canal are entitled to the thanks of the community for their praiseworthy efforts to improve their canal and suit it to the wants of commerce. I return to the members of it, and especially to Captain E. Lockhart and their late engineer, Mr. T. B. Scowden, my sincere thanks for valuable information and statistics, and their uniform courtesy to me and my party.

I desire also to thank the honorable Secretary of the Treasury for permitting me to see the history of the Louisville and Portland canal, made under his direction by Mr. W. D. Gallagher, and this gentleman for giving me the use of a set of drawings relating to the canal; also my entire party for their industry and good behavior, and especially to Mr. George R. Eichbaum, my chief assistant, than whom the government never had a more faithful, honest, conscientious, and energetic servant; and finally to the commissioners of Floyd county, Indiana, for their courtesy and kindness in tendering me an elegant office in their fine court-house free of charge.

The report of my assistant is added herewith, and shows all the details omitted by me to prevent unnecessary repetition.

I am, sir, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers, Brevet Major General U. S. A.

Brigadier General A. A. HUMPHREYS,
Chief Engineer Headquarters Corps of Engineers, Washington, D. C.

J 2.

SHIP CANAL AROUND THE FALLS OF THE OHIO.

NEW ALBANY, IND., *February* 8, 1868.

GENERAL: I have the honor to report that after having accompanied you during the preliminary examination of the vicinity of Jeffersonville and New Albany, and of the Louisville and Portland canal, I proceeded according to your orders to make the necessary surveys and estimates

for a ship canal around the falls of the Ohio river, on the Indiana side, and of the work necessary to complete the enlargement of the Louisville and Portland canal.

The surveys on the Indiana side have included the country between the Four-mile spring, above Jeffersonville, and the lower end of the slate bluff, below the mouth of Falling run, and from the river two miles back near to Very's mill, on Silver creek. This district is undulating and broken by Cane and Mill runs, Silver creek, and Falling run.

The work was begun at the mouth of Falling run. The line A was traced up the valley of this creek, thence across to Silver creek, near Very's mill, thence eastward to the bank of the river near the foot of Penn street, Jeffersonville, and thence along the river bank to the point of beginning.

Line B was begun at line A, in the valley of Falling run, near the Cromie dam, passed eastward across Silver creek to line A at station 424, north of Jeffersonville.

Line C was traced from line A at the corner of Main and Penn streets, Jeffersonville, along the river to mouth of Four-mile spring, thence northwardly across the Seven-mile slough, and thence westwardly to a point on line A, east of Jeffersonville.

From the river bank to lines A and C transverse lines were traced at intervals of from 200 to 1,000 feet between the mouth of Falling run and Four-mile spring, and levels taken every 100 feet on all the lines.

The topographical features having thus been ascertained and recorded upon the general map and the profiles, the lines of location were traced as follows:

Line F begins at the lower end of the slate bluff, below the mouth of Falling run, occupies the valley of that stream as far as the forks near Cromie's dam, in the northern part of New Albany, thence passes eastward along a valley south of Mr. De Pauw's house into the valley of Silver creek, thence along the stream to the iron bridge; thence eastward to a point 120 feet north of the flag-station on the New Albany and Jeffersonville railroad; thence along the north side of this railroad across the valley of Mill run into the valley of Cane run, below the tannery west of Jeffersonville, and thence to the river at the mouth of a small run at Port Fulton.

From Port Fulton to the flag-station the excavation would consist of clay, then gravel and thin limestone. The average depth of limestone excavation would be about 12 feet. On the remaining portions of the line the limestone has above slate rock and then clay.

Line E commences at the foot of Mulberry street, Jeffersonville, passes between Smith & Smyser's mill and the car works, continues across the plain to Camp Joe Holt, near the Big eddy; thence along the upper end of the marsh, across the bluff of limestone rock back of the cement mill to the mouth of Mill run, near Clarkesville, thence across Silver creek at the mouth of the Loop, and thence along the river-bottom lands to the edge of the water nearly opposite the New Albany glass works. From Clarkesville to the upper end of this line the excavation would consist of clay and gravel underlaid with limestone. On the remaining portion of the line the limestone dips southwestward and is overlaid with slate on which is clay.

Line D begins at station 368 of line F, on the west side of Jeffersonville, in the valley of Cane run; descends along that valley and curves northward into line E, near the Big eddy below Camp Holt. The material of the excavation would be the same as on the eastern part of line E.

Line G begins on the river shore at station 7 of line E, and passes

along the river bank in front of Smith & Smyther's mill, and then curves into line E at Camp Holt. The material of excavation is the same as on line D. Embankment and a protection would be needed on this line from station 0 to station 65.

Line J begins at line E, between Clarkesville and Silver creek, and curves into and continues in the valley of that stream until it strikes line F at the iron bridge. The material of excavation would be clay, slate, and limestone.

Line H begins at station 43 of line D, and strikes the river at Big eddy. The material of excavation would be clay, gravel, and limestone.

Line I begins at line E, near the lower end of the valley of Cane run, and extends to line H at the edge of the river bluff at Big eddy. The material of excavation would be the same as on line H.

Line K begins at section 129 of line E, above the cement mill, and continues along the limestone bluff to the river below the cement mill at the foot of the falls. The material of excavation would be limestone and clay.

Line L begins at line F at the iron bridge over Silver creek, curves eastward into the valley of Mill run; continues eastward as far as the bend of the river at the railroad crossing, thence passes along the line of the New Albany and Jeffersonville railroad to the valley of Cane run, and connects with line D above the railroad. The material of excavation would be clay, gravel, and limestone above Mill run, and clay, slate, and limestone on the rest of the line.

The different lines of location form, by their continuations, the following routes, viz:

ROUTE No. 1

Follows line F throughout. Length, eight miles and 2,460 feet; 13 bridges and six passing places required. The first deep cutting is between Fort Fulton and Cane run; next, between Cane run and Mill run, and then along the north side of the New Albany and Jeffersonville railroad to near the flag-station. From Silver Creek westward the excavation consists mostly of cuts across the bends of Falling run.

ROUTE No. 2.

This route begins at the upper end of line F, follows this line to line D, then line D to line L, then line L to line F, and then this line to its lower end. Length, eight miles and 2,328 feet; 16 bridges and six passing places required. The deep cutting is similar to that on route No. 1. It should be said of this route that line L crosses the New Albany and Jeffersonville railroad twice. Both of these crossings may be avoided by shifting the railroad track to the south side of Mill run, commencing at the east end of the railroad bridge at Silver creek, and ending at the present line of road between Mill and Cane runs. It is estimated that the cost of shifting the road will not exceed $30,000. The cost of the bridges at the two crossings of the railroad is estimated at $80,000. The saving by shifting the road would therefore be $50,000.

ROUTE No. 3.

This route begins at the upper end of line F, follows this line to line D, then line D to line E, then along line E to line J, then along line J to line F, and then this line to its lower end. Length, eight miles and 3,029 feet; 17 bridges and six passing places required. The deep cutting where this route follows is the same as on route No. 1. In addition,

there is deep cutting near Big Eddy bluff on line D, at the cement mill on line E, and on line J, between Clarkesville and Silver creek.

ROUTE No. 4.

This route begins at the upper end of line E, follows this line to line J, then follows line J to line F, and then follows this line to its lower end. Length, seven miles and 5,272 feet; 13 bridges and six passing places required. The first 4,000 feet would require protection-wall. The first deep cutting on this route is between the river and Camp Holt, and where it follows the lines J and F, as on route No. 3.

ROUTE No. 5.

This route begins at the upper end of line E, follows this line to line G, then this line to line E, then along E to line J, then this line to line F, and then follows this line to its lower end. Length, eight miles and 459 feet; 12 bridges and six passing places required. A protection-wall is needed for the first 7,200 feet of this route. The deep cutting on this route is the same as on route No. 4.

ROUTE No. 6.

This route begins at the upper end of line F, follows this line to line D, then this line to line E, and then follows this line to its lower end. Length, five miles and 259 feet; nine bridges and five passing places required. Deep cuttings on lines F, D, and E, as already stated, and between Springer's gut and the glass works.

ROUTE No. 7.

This route begins at the upper end of line E, and follows it to its lower end. Length, four miles and 2,680 feet; five bridges and four passing places required. Deep cutting as already above stated for line E.

ROUTE No. 8.

This route begins at the upper end of line E, follows it to line G, then along line G to line E, and then along this line to its lower end. Length, four miles and 3,144 feet; four bridges and four passing places required. Deep cutting as already above stated for lines E and G.

ROUTE No. 9.

This route begins at the upper end of line F, follows this line to line D, then this line to line E, then this line to line K, and this line to its end. Length, three miles and 1,219 feet; six bridges and three passing places required. Deep cutting on lines F, D, and E, as already stated, and at cement-mill bluff, on line K.

ROUTE No. 10.

This route begins at the upper end of line E, follows it to line G, and then this line to its lower end. Length, two miles 3,440 feet; three bridges and two passing places required. Deep cutting on lines E and K, as already stated.

ROUTE No. 11.

This route begins at the upper end of line E, follows it to line G, then follows this line to line E, then this line to line K, and then this line to its lower end. Length, two miles and 3,904 feet; two bridges and two passing places required. Deep cuttings as already stated for lines E, G, and K.

ROUTE No. 12.

This route begins at the upper end of line F, follows it to line D, then follows this to line H, and then follows this line to its lower end. Length, two miles and 3,837 feet; six bridges and two passing places required. Deep cutting as already stated for lines F and D, and on line H, between Cane run and Big eddy.

ROUTE No. 13.

This route begins at the upper end of line E, follows this line to line I, then follows this to line H, and then follows this to its lower end. Length, two miles and 742 feet; three bridges and two passing places required. Deep cutting as already stated for lines E, I, and H.

ROUTE No. 14.

This route begins at the upper end of line E, follows this line to line G, then this to line E, then this to line I, then this to line H, and then this line to its lower end. Length, two miles and 1,206 feet; two bridges and two passing places required. Deep cutting as already stated for lines E, G, I, and H.

The cost of these different routes, with a width of 90 and 120 feet, and with and without dams, is shown in detail in the following tables:

Table showing details of cost of routes on the

Items.	Price.	Route No. 1.		Route No. 2.	
		Amount.	Cost.	Amount.	Cost.
Grubbing and clearing.....acres..	$50 00	42	$2,100	59	$2,950
Earth excavations, and put into embankment where required.....cubic yards..	35	5,565,800	1,948,030	3,752,800	1,313,480
Slate rock excavation.....do.....	1 50	3,004,500	4,506,750	2,913,800	4,370,700
Solid rock excavation.....do.....	2 50	493,200	1,233,000	417,400	1,043,500
Solid rock excavation under water.....do.....	7 50	10,000	75,000	10,000	75,000
Concrete.....do.....	6 50	3,000	19,500	3,000	19,500
Lock masonry.....do.....	13 00	57,400	746,200	57,400	746,200
Lock gates, miter sills, and machinery.....pairs..	Variable.	5	115,000	5	115,000
Guard gates, miter sills, and machinery.....do..	Variable.	1	20,000	1	20,000
Guard gates, masonry and abutments...cubic yards..	13 00	7,000	91,000	7,000	91,000
Bridges, draw.....number..	40,000 00	13	520,000	16	640,000
Passing places.....do....	40,000 00	6	240,000	6	240,000
Land.....acres..	150 00	461	69,150	460	69,000
Wall next to the river.....cubic yards..	2 50	.....	.....	.....	.....
Pavement or slope wall.....do.....	1 00	.....	.....	.....	.....
Borrowed material.....do.....	35	.....	.....	.....	.....
Side walls.....do.....	2 50	437,300	1,093,250	419,000	1,047,500
Contingencies.....	.....	.....	531,020	.....	491,170
Total.....	.....	.....	11,210,000	.....	10,285,000

Items.	Price.	Route No. 8.		Route No. 9.	
		Amount.	Cost.	Amount.	Cost.
Grubbing and clearing.....acres..	$50 00	24	$1,200	17	$850
Earth excavations, and put into embankments where required.....cubic yards..	35	1,803,200	631,120	2,303,700	806,295
Slate rock excavation.....do.....	1 50	499,900	749,850	.....	.....
Solid rock excavation.....do.....	2 50	380,300	951,750	533,250	1,333,125
Solid rock excavation under water.....do.....	7 50	20,000	150,000	.....	.....
Concrete.....do.....	6 50	3,000	19,500	.....	.....
Lock masonry.....do.....	13 00	54,000	702,000	46,300	601,900
Lock gates, miter sills, and machinery.....pairs..	Variable.	5	107,500	5	92,000
Guard gates, miter sills, and machinery.....do....	Variable.	1	20,000	1	20,000
Guard gates, masonry and abutments..cubic yards..	13 00	7,000	91,000	7,000	91,000
Bridges, draw.....number..	40,000 00	4	160,000	6	240,000
Passing places.....do....	40,000 00	4	160,000	3	120,000
Land.....acres..	150 00	249	37,350	176	26,400
Wall next to the river.....cubic yards..	2 50	118,000	280,000	.....	.....
Pavement or slope wall.....do.....	1 00	25,000	35,000	.....	.....
Borrowed material.....do.....	35	106,000	37,100	.....	.....
Side walls.....do.....	2 50	222,500	556,250	102,400	256,000
Contingencies.....	.....	.....	236,38	.....	182,430
Total.....	.....	.....	4,925,00	.....	3,770,000

Indiana side, ninety feet wide, with the dams.

Route No. 3.		Route No. 4.		Route No. 5.		Route No. 6.		Route No. 7.	
Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.
64	$3,200	70	$3,500	69	$3,450	19	$950	25	$1,250
2,002,300	1,050,805	3,078,500	1,077,475	2,171,100	759,880	3,085,300	1,079,855	2,710,600	948,710
2,693,000	4,039,500	2,693,000	4,039,500	2,693,000	4,039,500	499,900	749,850	499,900	749,850
532,800	1,332,000	341,460	853,500	353,100	882,750	560,200	1,400,500	408,800	1,022,000
10,000	75,000	10,000	75,000	10,000	75,000	20,000	150,000	20,000	150,000
3,000	19,500	3,000	19,500	3,000	19,500	3,000	19,500	3,000	19,500
57,400	746,200	57,400	746,200	57,400	746,200	54,000	702,000	54,000	702,000
5	115,000	5	115,000	5	115,000	5	107,500	5	107,500
1	20,000	1	20,000	1	20,000	1	20,000	1	20,000
7,000	91,000	7,000	91,000	7,000	91,000	7,000	91,000	7,000	91,000
17	680,000	13	520,000	12	480,000	9	360,000	5	200,000
6	240,000	6	240,000	6	240,000	5	200,000	4	160,000
468	70,200	436	65,400	441	66,150	275	41,250	244	36,600
.....	.....	62,600	156,500	112,700	281,750	.....	.....	62,600	156,500
.....	.....	19,600	19,600	35,400	35,400	.....	.....	19,600	19,600
.....	.....	.....	.....	50,000	17,500	106,000	37,100	106,000	37,100
412,200	1,105,500	438,800	1,092,000	441,200	1,103,000	227,900	569,750	222,700	556,750
.....	487,095	.....	455,825	.....	448,920	.....	280,745	.....	251,640
.....	10,075,000	.....	9,610,000	.....	9,425,000	.....	5,810,000	.....	5,230,000

Route No. 10.		Route No. 11.		Route No. 12.		Route No. 13.		Route No. 14.	
Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.
23	$1,150	23	$1,150	2	$100	12	$600	11	$550
1,929,000	675,150	1,021,600	357,560	2,072,600	725,410	1,665,600	582,960	758,200	265,370
381,800	954,500	353,400	883,500	436,700	1,091,750	281,500	703,750	253,000	632,500
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
46,300	601,900	46,300	601,900	57,400	746,200	57,400	746,200	57,400	746,200
5	92,000	5	92,000	5	115,000	5	115,000	5	115,000
1	20,000	1	20,000	1	20,000	1	20,000	1	20,000
7,000	91,000	7,000	91,000	7,000	91,000	7,000	91,000	7,000	91,000
3	120,000	2	80,000	6	240,000	3	120,000	2	80,000
2	80,000	2	80,000	2	80,000	2	80,000	2	80,000
145	21,755	149	22,350	149	22,350	117	17,550	122	18,300
62,600	156,500	112,000	280,000	.....	.....	62,600	156,500	112,000	280,000
19,600	19,600	35,000	35,000	.....	.....	19,600	19,600	35,000	35,000
97,000	242,500	103,100	257,750	82,000	205,000	78,700	196,750	83,100	207,750
.....	153,950	.....	142,790	.....	168,190	.....	145,090	.....	128,330
.....	3,230,000	.....	2,945,000	.....	3,505,000	.....	2,995,000	.....	2,700,000

Table showing details of cost of routes on the

Items.	Price.	Route No. 1.		Route No. 2.	
		Amount.	Cost.	Amount.	Cost.
Grubbing and clearing ..... acres..	$50 00	42	$2, 100	59	$2, 950
Earth excavation, and put into embankments where required .... cubic yards..	35	5, 813, 200	2, 034, 620	3, 931, 6?0	1, 376, 060
Slate excavation ..... do	1 50	3, 295, 000	4, 942, 600	3, 187, 20.)	4, 780, 800
Solid rock excavation ..... do	2 50	662, 700	1, 656, 750	59), 300	1, 475, 750
Solid rock under water ..... do	7 5	10, 000	75, 000	10, 00)	75, 000
Side walls ..... do	2 50	366, 600	916, 500	352, 000	880, 000
Concrete ..... do	6 50	3, 0 0	19, 500	3, 000	19, 500
Lock masonry ..... do	13 00	57, 200	743, 600	57, 200	743, 600
Lock gates, miter sills, and machinery ..... pairs..	Variable.	5	115, 000	5	115, 000
Guard gates, miter sills, and m c inery ..... do...	20, 000 00	1	20, 000	1	20, 0 0
Guard gates, masonry, and abutments ... cubic yards..	13 00	7, 000	91, 000	7, 000	91, 000
Bridges, draw, complete ..... number..	40, 000 00	13	520, 000	16	642, 000
Passing places ....do....	40, 000 00	6	240, 000	6	240, 000
Land ..... acres..	150 00	461	69, 150	460	69, 000
Wall next to the river ..... cubic yards..	2 5)	.....	.....	.....	.....
Pavement r slope wall ..... do	1 00	.....	.....	.....	.....
Borrowed material ..... do	35	.....	.....	.....	.....
Contingencies	.....	.....	579, 280	.....	529, 340
Total	.....	.....	12, 025, 000	.....	11, 060, 000

Items.	Price.	Route No. 8.		Route No. 9.	
		Amount.	Cost.	Amount.	Cost.
Grubbing and clearing ..... acres..	$50 00	24	$1, 200	17	$850
Earth excavation, and put into embankments where required .. .. cubic yards..	35	1, 899, 900	664, 965	2, 402, 500	840, 875
Slate excavation ..... do	1 50	533, 500	800, 250	.....	.....
Solid rock excavation ..... do	2 50	564, 400	1, 411, 000	694, 400	1, 736, 000
Solid rock excavation under water ..... do	7 50	20, 000	150, 000	.....	.....
Side wal s ..... do	2 5)	184, 900	462, 250	76, 520	191, 300
Concrete ..... do	6 50	3, 000	19, 500	.....	.....
Lock masonry ..... do	13 00	53, 800	699, 400	46, 100	599, 300
Lock g tes, miter sills, and machinery ..... pairs..	Variable.	5	107, 500	5	92, 000
Guard gat-s, miter sills, and machinery ..... do...	Variable.	1	20, 000	1	20, 000
Bridges, draw, complete ..... number..	40, 000 00	4	160, 000	6	240, 000
Passing places ..... do	40, 000 00	4	160, 000	3	120, 000
Land ..... acres..	150 00	249	37, 350	176	26, 460
Wall next to the river ..... cubic yards..	2 50	112, 000	280, 000	.....	.....
Pavement or slope wall ..... do	1 00	35, 000	35, 000	.....	.....
Borrowed material ..... do	35	80, 000	28, 000	.....	.....
Guard gate, abutment, and masonry ..... do	13 00	7, 000	91, 000	7, 000	91, 000
Contingencies	.....	.....	257, 585	.....	202, 275
Total	.....	.....	5, 385, 000	.....	4, 160, 000

Indiana side, ninety feet wide, without the dams.

Route No. 3.		Route No. 4.		Route No. 5.		Route No. 6.		Route No. 7.	
Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.
64	$3,200	70	$3,500	69	$3,450	19	$950	25	$1,250
3,629,800	1,270,430	3,277,200	1,147,020	2,294,700	803,145	3,234,900	1,132,215	2,882,400	1,008,840
2,931,400	4,397,100	2,931,400	4,397,100	2,931,400	4,397,100	533,500	800,250	533,500	800,250
740,400	1,851,000	559,700	1,399,250	535,700	1,339,250	769,300	1,923,250	588,500	1,471,250
10,000	75,000	10,000	75,000	10,000	75,000	20,000	150,000	20,000	154,000
368,914	922,285	368,400	921,000	372,000	930,000	186,300	465,750	185,800	464,500
3,000	19,500	3,000	19,500	3,000	19,500	3,000	19,500	3,000	19,500
57,200	743,600	57,200	743,600	57,200	743,600	53,800	669,400	53,800	699,400
5	115,000	5	115,000	5	115,000	5	107,500	5	107,500
1	20,000	1	20,000	1	20,000	1	20,000	1	20,000
7,000	91,000	7,000	91,000	7,000	91,000	7,000	91,000	7,000	91,000
17	680,000	13	520,000	12	480,000	9	360,000	5	200,000
6	240,000	6	240,000	6	240,000	5	200,000	4	160,000
468	70,200	436	65,400	441	66,150	275	41,500	244	36,600
.....	.....	62,600	156,500	112,700	281,750	.....	.....	62,600	156,500
.....	.....	19,600	19,600	33,400	35,400	.....	.....	19,600	19,600
.....	.....	.....	.....	50,000	17,500	80,000	28,000	80,000	28,000
.....	526,685	.....	496,530	.....	482,155	.....	300,935	.....	275,810
.....	11,025,000	.....	10,430,000	.....	10,140,000	.....	6,340,000	.....	2,710,000

Route No. 10.		Route No. 11.		Route No. 12.		Route No. 13.		Route No. 14.	
Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.
23	$1,150	23	$1,150	2	$100	12	$600	11	$550
2,049,900	717,465	1,067,400	373,590	2,091,400	731,990	1,775,500	621,425	793,000	277,550
513,700	1,284,250	489,700	1,224,250	581,500	1,453,750	392,100	980,250	368,000	920,000
76,000	190,000	79,600	199,000	60,300	150,750	61,200	153,000	64,800	162,000
46,100	599,300	46,100	599,300	57,200	743,600	57,200	743,600	57,200	743,600
5	92,000	5	92,000	5	115,000	5	115,000	5	115,000
1	20,000	1	20,000	1	20,000	1	20,000	1	20,000
3	120,000	2	80,000	6	240,000	3	120,000	2	80,000
2	80,000	2	80,000	2	80,000	2	80,000	2	80,000
145	21,750	149	22,350	149	22,350	117	17,550	122	18,300
62,600	156,500	112,000	280,000	.....	.....	62,600	156,500	112,000	280,000
19,600	19,600	35,000	35,000	.....	.....	19,600	19,600	35,000	35,000
7,000	91,000	7,000	91,000	7,000	91,000	7,000	91,000	7,000	91,000
.....	166,985	.....	157,460	.....	186,460	.....	156,475	.....	147,000
.....	3,560,000	.....	3,255,000	.....	3,835,000	.....	3,275,000	.....	2,970,000

Table showing details of cost of routes on the

	Price.	Route No. 1.		Route No. 2.	
		Amount.	Cost.	Amount.	Cost.
Grubbing and clearing.....acres..	$50 00	45	$2,250	63	$3,150
Earth excavation and put into embankments where required.....cubic yards..	35	6,598,300	2,309,405	4,578,400	1,602,440
Slate excavation.....do.....	1 50	3,754,900	5,632,350	3,643,400	5,465,100
Solid rock excavation.....do.....	2 50	642,600	1,606,500	540,700	1,351,750
Solid rock excavation under water.....do.....	7 50	10,000	75,000	10,000	75,000
Side walls.....do.....	2 50	437,300	1,093,250	419,000	1,047,500
Concrete.....do.....	6 50	3,000	19,500	3,000	19,500
Lock masonry.....do.....	13 00	60,900	791,700	60,900	791,700
Lock gates, miter sillls, and machinery.....pairs..	Variable.	5	143,500	5	143,500
Guard gates, miter sills, and machinery .....do...	....do ...	1	25,000	1	25,000
Guard gates, masonry and abutments..cubic yards..	13 00	8,000	104,000	8,000	104,000
Bridges, draw, complete.....number..	50,000 00	13	650,000	16	800,000
Passing places.....do....	50,000 00	6	300,000	6	300,000
Land.....acres..	150 00	492	73,800	491	73,650
Wall next to the river.....cubic yards..	2 50	.....	.....	.....	.....
Pavement, or slope wall.....do.....	1 00	.....	.....	.....	.....
Borrowed material.....	35	.....	.....	.....	.....
Contingencies.....	.....	.....	648,745	.....	597,710
Total.....	.....	.....	13,475,000	.....	12,400,000

	Price.	Route No. 8.		Route No. 9.	
		Amount.	Cost.	Amount.	Cost.
Grubbing and clearing.....acres..	$50 00	26	$1,300	18	$900
Earth excavation and put into embankments where required.....cubic yards..	35	2,344,000	820,400	2,798,400	979,440
Slate excavation.....do.....	1 50	631,200	946,800	.....	.....
Solid rock excavation.....do.....	2 50	507,600	1,269,000	701,400	1,753,500
Solid rock excavation under water.....do.....	7 50	20,000	150,000	.....	.....
Side walls.....do.....	2 50	222,500	556,250	102,400	256,000
Concrete.....do.....	6 50	3,000	19,500	.....	.....
Lock masonry.....do.....	13 00	56,000	728,000	47,300	614,900
Lock gates, miter sills, and machinery.....pairs..	Variable.	5	134,000	5	115,000
Guard gates, miter sills, and machinery .....do...	....do ...	1	25,000	1	25,000
Guard gates, masonry and abutments...cubic yards..	13 00	8,000	104,000	8,000	104,000
Bridges, draw, complete.....number..	50,000 00	4	200,000	6	300,000
Passing places.....do....	50,000 00	4	200,000	3	150,000
Land.....acres..	150 00	265	39,750	188	28,200
Wall next to the river.....cubic yards..	2 50	112,000	280,000	.....	.....
Pavement, or slope wall.....	1 00	35,000	35,000	.....	.....
Borrowed material.....	35	80,000	28,000	.....	.....
Contingencies.....	.....	.....	278,000	.....	223,060
Total.....	.....	.....	5,815,000	.....	4,550,000

Indiana side, one hundred and twenty feet wide, with the dams.

Route No. 3.		Route No. 4.		Route No. 5.		Route No. 6.		Route No. 7.	
Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.
68	$3, 400	75	$3, 750	73	$3, 650	20	$1, 000	27	$1, 350
4, 226, 000	1, 479, 100	3, 821, 400	1, 337, 490	2, 784, 500	974, 575	3, 785, 600	1, 324, 960	3, 381, 000	1, 183, 350
3, 365, 400	5, 048, 100	3, 365, 400	5, 048, 100	3, 365, 400	5, 048, 100	631, 200	946, 800	631, 200	946, 800
708, 200	1, 770, 500	512, 600	1, 281, 500	474, 800	1, 187, 000	741, 000	1, 852, 500	545, 300	1, 363, 250
10, 000	7, 500	10, 000	75, 000	10, 000	75, 000	20, 000	150, 000	20, 000	150, 000
442, 200	1, 105, 500	436, 800	1, 092, 000	441, 200	1, 103, 000	227, 900	569, 750	222, 700	556, 750
3, 000	19, 500	3, 000	19, 500	3, 000	19, 500	3, 000	19, 500	3, 000	19, 500
60, 900	791, 700	60, 900	791, 700	60, 900	791, 700	56, 000	728, 000	56, 000	728, 000
5	143, 500	5	143, 500	5	143, 500	5	134, 000	5	134, 000
1	25, 000	1	25, 000	1	25, 000	1	25, 000	1	25, 000
8, 000	104, 000	8, 000	104, 000	8, 000	104, 000	8, 000	104, 000	8, 000	104, 000
17	850, 000	13	650, 000	12	600, 000	9	450, 000	5	250, 000
6	300, 000	6	300, 000	6	300, 000	5	250, 000	4	200, 000
499	74, 850	465	69, 750	470	70, 500	294	44, 100	250	39, 000
.....	.....	62, 600	156, 300	112, 700	281, 750	.....	.....	62, 600	156, 500
.....	.....	19, 600	19, 600	35, 400	35, 400	.....	.....	19, 600	19, 600
.....	.....	.....	.....	.....	.....	80, 000	28, 000	80, 000	28, 000
.....	589, 800	.....	557, 610	.....	537, 275	.....	332, 290	.....	304, 900
.....	12, 380, 000	.....	11, 675, 000	.....	11, 300, 000	.....	6, 960, 000	.....	6, 210, 000

Route No. 10.		Route No. 11.		Route No. 12.		Route No. 13.		Route No. 14.	
Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.
25	$1, 250	24	$1, 200	2	$100	13	$650	12	$600
2, 393, 700	837, 795	1, 356, 800	474, 880	2, 509, 200	878, 220	2, 070, 500	724, 625	1, 033, 300	361, 655
505, 700	1, 264, 250	468, 000	1, 170, 000	583, 700	1, 459, 250	374, 712	936, 780	337, 000	842, 500
97, 100	242, 500	103, 100	257, 750	82, 000	205, 000	78, 700	196, 750	83, 100	207, 750
47, 300	614, 900	47, 300	614, 900	60, 900	791, 700	60, 900	791, 700	60, 900	791, 700
5	115, 000	5	115, 000	5	143, 500	5	143, 500	5	143, 500
1	25, 000	1	25, 000	1	25, 000	1	25, 000	1	25, 000
8, 000	104, 000	8, 000	104, 000	8, 000	104, 000	8, 000	104, 000	8, 000	104, 000
3	150, 000	2	100, 000	6	300, 000	3	150, 000	2	100, 000
2	100, 000	2	100, 000	2	100, 000	2	100, 000	2	100, 000
154	23, 100	159	23, 850	159	23, 850	125	18, 750	130	19, 500
62, 600	156, 500	112, 000	280, 000	.....	.....	62, 600	156, 500	112, 000	280, 000
19, 600	19, 600	35, 000	35, 000	.....	.....	19, 600	19, 600	35, 000	35, 000
.....	181, 105	.....	168, 420	.....	219, 380	.....	172, 095	.....	163, 795
.....	3, 835, 000	.....	3, 470, 000	.....	4, 350, 000	.....	3, 540, 000	.....	3, 175, 000

Table showing details of cost of routes on the Indiana

	Price.	Route No. 1.		Route No. 2.	
		Amount.	Cost.	Amount.	Cost.
Grubbing and clearing.....acres..	$50 00	45	$2,250	63	$3,150
Earth excavation, put into embankments where required.....cubic yards..	35	6,846,600	2,396,310	4,758,200	1,665,370
Slate excavation.....do.....	1 50	4,125,900	6,188,850	3,993,800	5,990,700
Solid rock excavation.....do.....	2 50	885,100	2,212,750	781,500	1,953,750
Solid rock excavation under water.....do.....	7 50	10,000	75,000	10,000	75,000
Side walls.....do.....	2 50	366,600	916,500	352,000	880,000
Concrete.....do.....	6 50	3,000	19,500	3,000	19,500
Lock masonry.....do.....	13 00	60,700	789,100	60,700	789,100
Lock gates, miter sills, and machinery.....pairs..	Variable.	5	143,500	5	143,500
Guard gates, miter sills, and machinery.....do...	Variable.	1	25,000	1	25,000
Guard gates, abutments, and masonry..cubic yards..	13 00	8,000	104,000	8,000	104,000
Bridges, draw.....number..	50,000 00	13	650,000	16	800,000
Passing places.....do....	50,000 00	6	300,000	6	300,000
Land.....	150 00	492	73,800	491	73,650
Wall next to the river.....cubic yards..	2 50	.....	.....	.....	.....
Pavement, or slope wall.....do.....	1 00	.....	.....	.....	.....
Borrowed material.....do.....	35	.....	.....	.....	.....
Contingencies.....	.....	.....	703,440	.....	652,280
Total.....	.....	.....	14,600,000	.....	13,475,000

	Price.	Route No. 8.		Route No. 9.	
		Amount.	Cost.	Amount.	Cost.
Grubbing and clearing.....acres..	$50 00	26	$1,300	18	$900
Earth excavation, put into embankments where required.....cubic yards..	35	2,455,700	859,495	2,898,100	1,014,335
Slate excavation.....do.....	1 50	676,000	1,014,000	.....	.....
Solid rock excavation.....do.....	2 50	752,900	1,882,250	926,600	2,316,500
Solid rock excavation under water.....do.....	7 50	20,000	150,000	.....	.....
Side walls.....do.....	2 50	184,900	462,250	76,520	191,300
Concrete.....do.....	6 50	3,000	19,500	.....	.....
Lock masonry.....do.....	13 00	55,800	725,400	47,100	612,300
Lock gates, miter sills, and machinery.....pairs..	Variable.	5	134,000	5	115,000
Guard gates, miter sills, and machinery.....do...	Variable.	1	25,000	1	25,000
Bridges, draw.....number..	50,000 00	4	200,000	6	300,000
Passing places.....do...	50,000 00	4	200,000	3	150,000
Land.....	150 00	265	39,750	188	28,200
Wall next to the river.....cubic yards..	2 50	112,000	280,000	.....	.....
Pavement or slope wall.....do.....	1 00	35,000	35,000	.....	.....
Borrowed material.....do.....	35	50,000	17,500	.....	.....
Guard gate, abutments, and masonry.....do.....	13 00	8,000	104,000	80,000	104,000
Contingencies.....	.....	.....	315,555	.....	247,465
Total.....	.....	.....	6,475,000	.....	5,105,000

side, one hundred and twenty feet wide, without the dams.

Route No. 3.		Route No. 4.		Route No. 5.		Route No. 6.		Route No. 7.	
Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.
68	$3,400	75	.....	73	$3,650	20	$1,000	27	$1,350
4,406,000	1,542,100	4,022,600	$1,407,910	2,925,500	1,023,925	3,936,200	1,377,670	3,552,800	1,243,480
3,669,600	5,504,400	3,669,600	5,504,400	3,669,600	5,504,400	676,000	1,114,000	676,800	1,014,000
995,000	2,488,500	750,000	1,875,000	718,200	1,795,500	1,030,000	2,575,000	784,100	1,961,750
10,000	75,000	10,000	75,000	10,000	75,000	20,000	150,000	20,000	150,000
358,914	922,285	368,400	921,000	372,000	930,000	186,000	465,750	185,800	464,500
3,000	19,500	3,000	19,500	3,000	19,500	3,000	19,500	3,000	19,500
50,700	789,100	60,700	789,100	60,700	789,100	55,800	725,400	55,800	725,400
5	143,500	5	143,500	5	143,500	5	134,000	5	134,000
1	25,000	1	25,000	1	25,000	1	25,000	1	25,000
8,000	104,000	8,000	104,000	8,000	104,000	8,000	104,000	8,000	104,000
17	850,000	13	650,000	12	600,000	9	450,000	5	250,000
6	300,000	6	300,000	6	300,000	5	250,000	4	200,000
499	74,850	465	69,750	470	70,500	294	44,100	260	39,000
.....	.....	62,600	156,500	112,700	281,750	.....	.....	62,600	156,500
.....	.....	19,600	19,600	35,400	35,400	.....	.....	19,600	19,600
.....	.....	.....	.....	.....	.....	50,000	17,500	50,000	17,500
.....	658,365	.....	610,990	.....	598,775	.....	377,080	.....	326,420
.....	13,500,000	.....	12,675,005	.....	12,300,000	.....	7,835,000	.....	6,852,000

Route No. 10.		Route No. 11.		Route No. 12.		Route No. 13.		Route No. 14.	
Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.	Amount.	Cost.
25	$1,250	24	$1,200	2	$100	13	$650	12	$600
2,514,600	880,110	1,417,600	496,160	2,604,300	911,505	2,180,300	763,105	1,083,100	379,085
681,200	1,703,000	649,500	1,623,750	777,300	1,943,000	523,900	1,309,750	490,100	1,225,250
76,000	190,000	76,600	199,000	60,300	150,750	61,200	153,000	61,800	162,000
47,100	612,300	47,100	612,300	60,700	789,100	60,700	789,100	60,700	789,100
5	115,000	5	115,000	5	143,500	5	143,500	5	143,500
1	25,000	1	25,000	1	25,000	1	25,000	1	25,000
3	150,000	2	100,000	6	301,000	3	150,000	2	100,000
2	100,000	2	100,000	2	100,000	2	100,000	2	100,000
154	23,100	159	23,850	159	23,850	125	18,750	130	19,500
62,600	156,500	112,000	280,000	.....	.....	62,600	156,500	112,000	280,000
19,600	19,600	35,000	35,000	.....	.....	19,600	19,600	35,000	35,000
8,000	104,000	8,000	104,000	8,000	104,000	8,000	104,000	8,000	104,000
.....	201,140	.....	194,740	.....	234,195	.....	187,045	.....	186,965
.....	4,280,000	.....	3,910,000	.....	4,725,000	.....	3,920,000	.....	3,550,000

In the calculations of the quantities as given in the above tables, allowance was made for a descent of the bottom of the canal, on routes over four miles long of four and a half feet, on those three miles long of three and a half feet, and on the shorter routes three feet.

Without the dams the lockage at the foot of the line F would be 30 feet; at the foot of line E, 28 feet; at the foot of line K, 24 feet, and at the foot of line H, 20 feet. With the dams the lockage would be 33, 27, 23, and 23 feet respectively. To determine the relative value and availability of the several routes at their ends, complete surveys were made and levels taken of the falls, and of the bed of the river from the mouth of Four-mile Spring creek to the lower end of the slate bluff below Falling run. The Big Eddy outlet line, H, is not feasible, as there is a fall of four feet to the foot of the falls, and in consequence of the whirling eddies which at times prevail, the dam below will not improve it much, if any.

The outlet between the cement mill and Mill run (line K) will be a good one if the dam below is constructed, because then there will be sufficient water at the lowest stages. Without the dam it would be necessary either to excavate a channel through the rocky bar between Sandy island and the Indiana shore, or the boats would be compelled to pass obliquely across the Indiana and middle-chute channels into the channel used by boats passing around the south side of Sandy island, which route, at every freshet, would be liable to obstructions by mud and drift deposits.

With the dam below, the outlet near the glass works (line E) would be a good one; without the dam considerable channel excavation would be necessary below it to deep water.

The outlet at Falling run is in every way an excellent one.

All the routes on the Indiana side begin at one of two points. The upper one is at Fort Fulton, (line F;) the other is at the foot of Mulberry street, Jeffersonville, (line E.) The water of the river in front of both is deep, and only a little excavation is necessary to make either safe and accessible. The lower one has the great advantage over the upper one in this, that the routes which begin at it avoid running through the town of Jeffersonville, and thus save many bridges and much annoyance.

As will be seen from the above, the great and vital objections to almost every suitable route on the Indiana side are the great lengths, numerous bridges, great expense, and the necessity of receiving into them one or all of the four creeks, viz: Falling run, Silver creek, Mill run and Cane run, neither of which could be passed under the canal.

The only two routes which approximate to feasibility to the Louisville and Portland canal, are routes numbers 10 and 11; the latter more so than the former.

The surveys and measurements of work yet to be done to complete the enlargement and extension of the Louisville and Portland canal were begun on the 16th of October, 1867, and ended on the 31st of same month.

The original plan of the company was to enlarge the canal to 100 feet width of water-way. This was afterwards changed by the board of directors to 90 feet width of water-way; the depth of water to be six feet over upper miter sill of upper lock; the abrupt angle of the present canal to be removed, and regular easy curves substituted. There were to be three passing places—the upper one to be 500 feet long, the middle one 350 feet, and that opposite the head of the old locks to be formed of capacity to chamber two or more boats, by taking away the

present dry-dock. The locks to be constructed 375 feet from quoin to quoin, and 80 feet width of chamber. A pair of guard gates and abutments to be built at the head of canal as high as the canal embankment. A dam or crib to be built next to upper end of pier at upper end of canal. Two draw-bridges to be constructed, one at the upper lock, the other opposite Elm Tree garden.

The above are the principal items of work to be done.

The excavation for enlargement to be at south side of canal. The embankments to be formed on both sides of the canal by setting off a horizontal berme 15 feet wide from the face of the vertical dry wall to the base of the first slope, which slope will be carried up at one and a half to 1.15¾ feet high to a second berme 15 feet wide, extending to a second slope of the same form and height as the first, which will reach the summit of the embankment 49½ feet above the bottom of canal, two feet higher than the highest known freshet. The outside of embankment to have a slope of one and a half to one descending to the natural surface of the ground. The rock in the bed of the river below the new outlet lock to be excavated to form a wide and safe channel.

The surveys and measurements were commenced by tracing lines and taking heights of top of bank on each side of the canal, at stations 100 feet apart throughout the length of canal; at each station cross-sections were taken on each side of canal to outside of bank. The width of water-surface in canal was measured at each station. The height of surface of water in the canal was carefully taken, and the depth of water to the rock measured at each station, the highest point of rock on the bottom being two feet eight inches above level of miter sill of new guard gates. The depth of mud deposit on the rock was also measured at each station.

The top and bottom widths of water-surface range from 53 to 68 feet; the average width throughout being 63 feet.

Cross-sections were taken at each station of 100 feet along the branch canal, the new locks, and the channel below the new outlet lock.

It was found that, in addition to the excavation of rock in the channel, a large quantity of excavation is necessary on the land side, so that the center line of the new locks may be continued straight through to the present channel of the river.

The calculations of quantities have been made in accordance with the plan of the company as heretofore described, with the exception of an inclination of canal bottom, causing at the head of the new locks a total descent of two feet, which has been allowed in order to facilitate the washing out of mud deposits, and to preserve sufficient depth of water at times when the frequent passage of boats may have lowered the surface of water near the locks. The masonry of the new locks is completed excepting laying some of the stone for the lower miter wall of the outlet lock. The gates and miter sills are complete, ready to be fitted together, the materials being under cover near the locks.

The draw-bridge at the upper lock and that opposite Elm Tree garden are complete and in use.

The new guard-gates and abutments have been built to a height of 28 feet above bottom. The portion of the embankment next the river extending westward from the guard-gate 2,500 feet in length, has at top an average height of 27 feet above canal bottom.

The estimated cost of completing the enlargement and extension is as follows:

Detailed estimates for completing the Louisville and Portland canal extension according to last plan of the company.

	Price.	Amount.	Cost.
CANAL PROPER.			
Earth excavation.....cubic yards..	$0 35	102,660	$35,931
Solid rock.....cubic yards..	2 50	121,800	304,500
Loose rock and dry wall excavation.....cubic yards..	75	37,000	27,750
Loose rock and filling.....cubic yards..	2 00	5,000	10,000
Vertical dry wall.....cubic yards..	2 50	37,100	92,750
Earth sediment in canal.....cubic yards..	35	48,300	17,020
Repairs and improvement of guard gate.....	.....	.....	6,000
Lumber in cribs.....feet, board measure..	50 00	180,000	9,000
Wrought-iron work.....pounds..	25 00	16,000	4,000
Pavement of slopes.....square yards..	1 00	40,000	40,000
Macadamizing.....square yards..	60	5,000	3,000
BRANCH.			
Earth excavation.....cubic yards..	35	169,050	59,167
Solid rock excavation.....cubic yards..	2 50	71,900	179,750
Solid rock excavation in channel.....cubic yards..	2 50	10,000	25,000
Solid rock excavation under water.....cubic yards..	7 50	22,000	165,000
Loose rock and dry wall excavation.....cubic yards..	75	690	517
Vertical dry wall.....cubic yards..	2 50	20,000	50,000
Pavement of slope.....square yards..	1 00	24,000	24,000
Macadamizing.....square yards..	60	3,000	1,800
Wrought-iron work.....pounds..	25	64,000	16,000
Cast-iron work.....pounds..	08	176,000	14,080
Finishing hanging of lock gates and placing miter sills.....	.....	.....	30,000
Contingencies.....	.....	.....	62,735
Total.....	.....	.....	1,178,000

Estimate for completing the Louisville and Portland canal extension on the plan originally adopted, but only 90 feet wide.

	Price.	Amount.	Cost.
Amount of estimate as above.....	.....	.....	$1,178,000
Amount of embankment (additional).....cubic yards..	$0 35	79,440	27,804
Guard gate masonry (additional).....cubic yards..	13 00	5,200	67,600
One pair of new guard gates.....	.....	.....	16,000
Contingencies.....	.....	.....	5,596
Total.....	.....	.....	1,295,000

Estimate for completing the Louisville and Portland canal extension properly constructed, i. e. with river bank raised four feet above the highest known freshet and a descent of one foot per mile.

	Price.	Amount.	Cost.
Amount of estimate as above.....	.....	.....	$1,295,000
Earth embankment (additional).....cubic yards..	$0 35	16,000	5,600
Solid rock excavation.....cubic yards..	2 50	35,200	88,000
Contingencies.....	.....	.....	5,400
Total.....	.....	.....	1,394,000

The accuracy of the lines traced by the surveyors Mr. H. A. Leavitt and his assistant Mr. L. P. Judson, and of the leveling done by Captain A. Stein and his assistant, Mr. William M. R. French, has been verified by several trial lines.

The topographical sketches were taken by Mr. F. R. Leavitt. An elaborate map has been completed by your accomplished draughtsman Colonel P. J. Schopp, on which he has correctly delineated the results of the field-work and profiles of the several routes, and drawings of the locks and guard-gates are in course of preparation.

I am, sir, very respectfully, your obedient servant,

GEORGE R. EICHBAUM,
Civil Engineer, Chief Assistant.

Brevet Major General G. WEITZEL,
Major of Engineers United States Army.

J 3.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, August 26, 1868.

SIR: I have the honor to submit herewith my annual report on the "examination and surveys on the Tennessee river," for the fiscal year ending June 30, 1868.

Operations in the field were commenced in September, 1867, and concluded in December of the same year. On the 21st of February, 1868, I made my special report, in accordance with instructions from headquarters corps of engineers, and closed the survey in March, 1868, after the field-notes, drawings, and filing of the original records had been completed.

In consequence of the hurry in which my special report of February last was prepared, I overlooked Mr. Gaw's estimates for removing the obstructions at Seven-mile island, (four miles below Florence, Alabama.) The sum required to remove this obstruction will be, I think, $25,000.

The total amount required for the entire completion of the work, I estimate as follows:

1. To improve the Tennessee river from its mouth to Florence, Alabama, $40,000.

2. To enlarge and repair the existing canal from Lamb's to Campbell's ferries, $1,500,000.

3. To improve the river from Chattanooga, Tennessee, to Decatur, Alabama, $90,000.

In order to enable me to get material for a proper estimate for canals around the Elk river, and Little Muscle shoals, I recommend that another survey be made of those points. I estimate that this survey, properly made, would cost $10,000.

The total amount therefore required, as far as I now can state, is $1,640,000.

The amount that has been set apart for this work for the fiscal year ending June 30, 1869, is $85,000. $40,000 will be expended in improving the river from its mouth to Florence, Alabama, and $45,000 in improving the river between Chattanooga, Tennessee, and Decatur, Alabama.

During the fiscal year ending June 30, 1870, the following amounts can be profitably expended:

1. To enlarge and repair the existing canal from Lamb's to Campbell's ferries, $500,000.

2. To improve the Tennessee river from Chattanooga, Tennessee, to Decatur, Alabama, $45,000.

3. To resurvey the river from Brown's ferry to Florence, Alabama, $10,000.

The number of collection districts through which the river runs, I am unable to give.

The nearest port of entry is Louisville, Kentucky. The amount of revenue collected at this port during the fiscal year ending June 30, 1868, was $201,350 48.

The whole commerce and navigation of the Mississippi river and its tributaries would be benefited by improving the Tennessee river. Reference is made to appendix, herewith, showing the total cost of the survey.

I am, sir, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers, Brevet Major General U. S. A.

Brig. Gen. and Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers, Headquarters Corps of Engineers,
Washington, D. C.

APPENDIX.

Statement showing the total cost of the examinations and surveys on the Tennessee river, for the fiscal year ending June 30, 1868.

Hired men		$8,781 98
Boats, bedding and stationery		1,214 40
Mileage		146 90
Transportation of instruments		20 60
Postage		13 62
Carrying dispatches		3 00
Commutations, quarters, and fuel		106 00
Expenditures		10,286 50
Deduct bedding to hired men	126 00	
Deduct sales of stationery and boats	182 45	
		308 45
Cost of the work		9,978 05

RECEIPTS.

June 30, 1868. From the treasury during the year		$10,000 00
Deposited to the credit of the U. S. Treasurer.	Sales of boats and stationery	182 45
(Stopped on rolls,) bedding to hired men		126 00
(Stopped on rolls,) revenue tax from salaries		160 50
Total		10,468 95

DISBURSEMENTS.

June 30, 1868. Expenditures as above	$10,286 50
Deposited to credit of the United States Treasurer, (sundry times)	182 45
Total	10,468 95

Respectfully submitted.

G. WEITZEL,
Major of Engineers, Brevet Major General U. S. A.

J 4.

NEW ALBANY, INDIANA,
February 20, 1868.

GENERAL: My instructions for the survey of the Tennessee river were contained in the letter from the engineer department, dated July 24, 1867. This letter inclosed a copy of an act making appropriation for the repair, preservation and completion of certain public works, &c., approved March 2, 1867, a copy of a letter recommending Mr. W. B. Gaw (late colonel United States volunteers) for the position of engineer to conduct the survey, favorably indorsed by the Hon. Horace Maynard, and a copy of the letter of the committee of the people of East Tennessee, indorsed by the Hon. W. B. Stokes, urging the speedy commencement of the survey of Muscle shoals. I was supplied from time to time from the headquarters corps of engineers with copies of the following reports, viz: Report of the board of internal improvement on the examination of the Muscle and Colbert's shoals, Tennessee river, May 14, 1828, with six original sheets of survey; report of the board of engineers, December 18, 1830, of the "projected improvement of the Tennessee river from Brown's ferry to Florence ferry;" estimates for improvment of Tennessee river by the board of engineers, March 25, 1831; Lieutenant Colonel James Kearney's report on the "condition of the Tennessee river," June, 1838, (memorial of general assembly of Alabama, &c.;) report of Colonel S. H. Long, topographical engineers, on the survey and improvement of Holston and Tennessee river, (without date;) report of Colonel J. McClellan, topographical engineers, on the "improvement of Tennessee river," September 1, 1853, and report of boards of engineers on the improvement of Tennessee river, September 1, 1854.

Immediately upon the receipt of the letter of instructions I tendered the position of chief assistant to conduct the survey to Colonel William B. Gaw, but he being (unknown to me) at the time assistant on the New Orleans, Mobile and Chattanooga railroad, first required the permission of the chief engineer of the road to accept the appointment. But as this gentleman was engaged with his locating party in the salt marshes intervening between New Orleans and Bay St. Louis, Mississippi, and consequently beyond the reach of mails, Colonel Gaw was compelled to go there to get the required authority. In consequence of the delay thus occasioned, and the necessary delay caused in requiring for and receiving the instruments, and the approval of the scale of wages proposed by me, the field-work did not begin until the middle of September, 1867.

At the time the river was quite low and it became lower during the progress of the survey, so that we think we had one of the most favorable seasons known for our work.

Immediately upon the commencement of the field-work, the gentleman in charge of the transit became sick; a few days after the topographer was drowned while crossing Tumbling shoals, and the leveler being compelled, in his efforts to save the life of the topographer, to jump into the river, was prostrated by an attack of the fever. These unforeseen and unavoidable accidents delayed the party fully a month. This fact, together with the limited amount of money set apart to defray the expenses of this work led me to fear that but a very partial report could be rendered. It is therefore very gratifying to me to present herewith as an appendix so full a report as Colonel Gaw has given.

With the plans suggested by him for the improvement of the obstacles, of which he gives a list in detail, I am fully agreed. The dimensions of the canals proposed around Elk river, Big Muscle, and Little Muscle shoals were fixed by me in the belief that they should at least be suitable for a steamboat of 750 tons burden.

The important facts otherwise touched upon in this report I also indorse.

With regard to the examinations recommenced for the purpose of ascertaining the feasibility of water connection between the Tennessee and Coosa rivers, and the French Broad and Catawaba rivers, I am not able to give an opinion, but I think such subjects should only be considered in connection with the more general system of internal improvements, and not in connection with the work with which I was charged; but I am firmly of the opinion that the estimates presented are entirely too low, I consider an addition to them of 50 per cent. for contingencies as not exorbitant.

The project which I submit is that the operations for the fiscal year ending June 30, 1869, be as follows:

1. To improve the Tennessee river from its mouth to Florence, Alabama. This, according to Colonel Gaw's estimates, would require $9,592. According to my views it would require, in round numbers, $15,000.

2. To enlarge and repair the existing canal from Lamb's to Campbell's ferries. This, according to Colonel Gaw, would require $1,001,817 50. According to my ideas, $1,500,000, of which $500,000 would be required during the year above mentioned.

3. To improve the river from Chattanooga, Tennessee, to Decatur, Alabama, which, according to Colonel Gaw, would cost $58,901. According to my views, $90,000.

4. To make another and detailed survey for canals around the Elk river and Little Muscle shoals, with a view to get a more accurate view than is herewith presented. For this purpose I estimate that $10,000 would be sufficient. The total amount which I recommend to be appropriated for the fiscal year ending June 30, 1869, for the improvement of the Tennessee river is therefore $605,000, and for the survey above mentioned $10,000. In addition to the many good reasons given in the appended report for making the improvement at this time, and to those which have been given by the many able men who have reported on this subject during the last 40 years, there occurs to me that not only would a work be done which should have been done years ago, but which would have repaid the government a large interest, but that it would be the means of giving a poverty-stricken community an opportunity to recover from the disastrous effects of a war, and give employment to a large class of deserving people who are said to be out of employment.

I am perfectly confident that if the distinguished soldiers who commanded our armies operating along the line of this river, during the late war, would be called upon to testify in this matter, that it would be

found that enough money would have been saved to the quartermaster's department by an improved river, in one campaign, to have trebly paid the expense of doing the work.

I conclude (to avoid repetition) by simply, in addition hereto, submitting the report of my chief asssistant, W. B. Gaw, to whom I desire to return my thanks for the intelligence and ability displayed in it.

I am, sir, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers, Brevet Major General U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, Headquarters Corps of Engineers.
Washington, D. C.

J 5.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, August 17, 1868.

SIR: My special report, dated February 20, 1868, on the "examinations and surveys on the Tennessee river," was closed in a great hurry, so as to get it to headquarters of the corps as early as the friends of the work desired. In reading it over again upon the receipt of the printed copies, with a view to prepare my advertisement for proposals, I found that in saying that Mr. Gaw's estimate would require only $9,592 to improve the river below Florence, Alabama, (see page 3 of the printed report,) I overlooked his item for improving Seven-mile island, (four miles below Florence, Alabama,) altogether. (See page 17 of the printed report.)

This item is $17,480 50, according to Mr. Gaw's estimate, but should be fully $25,000 according to my views.

Now it is of the first importance that the river from Florence down should be first improved. This, then, would open the river to the foot of the great series of shoals.

I therefore request authority to apply $40,000 of the appropriation just made for the improvement of the Tennessee river to its improvement, from its mouth to Florence, Alabama, and the balance ($45,000) to its improvement between Chattanooga, Tennessee, to Decatur, Alabama.

I believe the Hon. Secretary of War has full power to grant this authority.

I am, sir, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers, Brevet Major General U. S. Army.

Brig. Gen. and Bvt. Maj. Gen. A. A HUMPHREYS,
Chief of Engineers, Headquarters Corps of Engineers,
Washington, D. C.

J 6.

Report on examinations and surveys on the Tennessee river, by William B. Gaw, esq., civil engineer, chief assistant engineer.

CHATTANOOGA, TENN., *February* 11, 1868.

GENERAL: I have the honor to submit the following report of the survey of the Tennessee river from Chattanooga, Tennessee, to its mouth, at Paducah, Kentucky:

In obedience to your letter of August 1, 1867, appointing me your

chief assistant engineer, with instructions to conduct the survey and examination of the obstructions to the navigation of the Tennessee river below Chattanooga, and to subsequent instructions from you, a party was organized at this point, consisting of the following members, under my direction: F. S. Wallace, sub-assistant engineer; A. T. Phelps, transit man; W. P. Homan, leveler; Edward McDermott, topographer, (with an assistant;) Captain T. J. Woodward, pilot; and a sufficient number of rodmen, ax-men, boatmen, &c.

A covered barge, for the accommodation of the party, and several small cutters for hydrographical purposes, with all the necessaries for the survey, having been procured at this point, the party commenced operations on Wednesday, the 18th day of September, 1867, at the levee at the foot of Market street, Chattanooga. The river was at a very low stage at the time of commencing the survey, and continued steadily falling for some weeks, affording peculiar facilities for observation.

Mr. Phelps, the transit-man, was taken ill upon the day the survey commenced, and subsequently (October 31) retired from the survey, in consequence of his continued illness, when Mr. J. C. Long was appointed transit-man to fill the vacancy.

On the 7th of October, the party then being engaged in the reconnoissance of Tumbling shoals, 13 miles below Chattanooga, Mr. Edward McDermott, topographer, was drowned while attempting to pass the shoals in a small boat. At the same time Mr. W. P. Homan, leveler, was taken ill, and did not report for duty until November 8, at Elk River shoals. October 21, Mr. F. T. Hampton joined the party as topographer, vice McDermott, deceased.

In consequence of this series of misfortunes, the party was delayed at the Suck, 15 miles below Chattanooga, until October 26, at which time we left for Elk River shoals. We arrived at Decatur, Alabama, on the 3d of November, and at the head of Elk River shoals on the 7th, reaching Florence, at the foot of Muscle shoals, on the 28th November. The party arrived at Paducah, Kentucky, December 20, and was disbanded on the 22d, with the exception of the engineers and pilot, who, by your instructions, were retained to assist in reducing the notes of the survey.

In this survey, every obstruction known to river men was carefully examined, its peculiar features noted, and plans and estimates made for its removal; but the greatest care was bestowed upon the survey of the Tumbling shoals, and the Suck, 13 and 15 miles below Chattanooga, and upon that of Elk River, Muscle, and Colbert's shoals, near Decatur, Alabama, of which maps and hydrographical charts have been carefully constructed, and the existing difficulties of navigation illustrated by accurate sketches.

In consequence of the limited time afforded for the completion of this survey, embracing a portion of the river 538 miles in length, which it was important to accomplish by the 1st of January, 1868, and of the delay caused at the outset by the death of one of the most important members of the party, and the continued illness of several others, it has not been possible to present so full a report as the importance of the subject demands; but upon the principal obstructions, whose removal is absolutely necessary, it is believed that the report is at least full if not absolutely complete.

Sufficient data have been obtained for a map of the entire river from Chattanooga to its mouth; but as upon a scale of two inches to the mile, the map would be more than 90 feet long, the time allowed would not permit of its construction. If, after the report with the accompanying maps has been presented to the department, a map of other parts of the

river is desired, it can be constructed from the data collected by this survey.

Below is appended a list of obstructions to navigation from Chattanooga to Paducah, as surveyed by the party under my instructions, with plans suggested for their improvement, and estimates of the cost of removing them, together with a consolidated tabular statement, showing at one glance the entire estimated cost of removing every, even the least, obstruction to the navigation of the river at all seasons.

ROSS TOWHEAD, (two and a half miles from Chattanooga.)

The obstructions at this place consist of two rock reefs, upper and lower, just above the upper end of the towhead, of a very hard, flinty nature, dipping about 30°, and a grand bar a short distance below the towhead. There is a wing-dam running from the upper end of the towhead towards the right bank, at an angle of about 60° with the general course of the river. This wing-dam is not long enough to confine the required amount of water to the left chute of the towhead to cut out the grand bar below.

The improvement proposed is the excavation of the reefs of rock and the extension of the wing-dam 300 feet further up stream, the estimate for which is as follows:

940 cubic yards rock excavation, at $2 50	$2,350 00
940 cubic yards wing-dam built of excavated material, at 60 cts.	564 00
60 cubic yards wing-dam, at $1 50	90 00
Total,	3,004 00

LOOKOUT SHOALS, (five miles below Chattanooga.)

At this place the river becomes very shallow, there being but two feet of water in the channel at the lowest stage of the river. The bottom is composed of sand and gravel, and can be easily cut away. The improvement proposed is by a wing-dam, extending from a sand-bar on the right bank downwards and outwards for a length of 400 feet, it being six feet wide on top, three feet deep, and having side slopes of one and a half to one.

Estimate.

465 cubic yards riprap in wing-dam, at $1 50	$697 50

BURROUGHS'S BAR, (11 miles below Chattanooga.)

This obstruction is a hard sandstone reef, extending from the right bank of the river to Williams's island, a distance of 300 feet. There are 16 inches of water on the reef at the lowest stages of the river in the channel, and a current of four miles an hour. The fall in the surface of the water from 100 feet above the bar to 100 feet below is nine and three-quarter inches.

The results of the survey indicate the construction of a wing-dam 500 feet in length from the head of Williams's island, two and a half miles above the bar, to the left bank of the river, throwing all the water into the right chute.

This dam will be built on a gravel bar that extends from the head of the island to the left bank, on which there are but four inches of water at the lowest stage of the river.

The building of the dam will increase the depth of water on the bar at least four inches, making 20 inches at low water. Below the bar or

reef the water is shoal for about 200 feet, with a gravel bottom that will be washed out to a sufficient depth by building the dam and excavating a channel in the rock reef.

The following is an estimate for the improvement of this obstruction, to make a channel 100 feet wide and three and a half feet deep:

900 cubic yards riprap in wing-dam, at $1 50	$1,350 00
335 cubic yards hard sandstone excavation at Burroughs's bar, at $2	670 00
Total	2,020 00

TUMBLING SHOALS, (13 miles below Chattanooga,)

are the most important obstacle to navigation in the Tennessee river, between Chattanooga and Muscle shoal. They are formed by a series of falls over coarse sandstone reefs and by large boulders scattered irregularly about, varying from a few feet to many yards in dimensions. The width of the river at the head of the shoals or first fall is 700 feet, but the channel approaches within 100 feet of the left bank it is five and a half feet deep, but only 40 feet wide, and very swift, at least 12 miles an hour for a distance of 50 feet. Six hundred feet below the first reef or fall is Broadax ledge. The channel at this point is close to the left shore, is 40 feet wide and six feet deep. The fall from the head of the shoals to this point is two and a half feet. There is always plenty of water between these two points. Eight hundred feet below Broadax ledge is the third and last fall of Tumbling shoals. On this fall there are but three feet of water at the lowest stage of the river, and a channel of 40 feet in width. The fall from Broadax ledge to Rocky Point, 1,000 feet below the third fall, is one foot and five inches, making the entire fall in Tumbling shoals 3 feet and 11 inches. Opposite Rocky Point there is a large rock in the centre of the channel, known as the "Holston rock," and considered very dangerous by Tennessee river pilots.

The improvements required at Tumbling shoals are the removal of the boulders at the first fall, excavation of the reef called Broadaxe ledge, removal of boulders at the third fall, and the removal of "Holston rock," the estimate for which is as follows:

150 cubic yards coarse sandstone boulders, first fall, at $2 50	$375 00
100 cubic yards coarse sandstone reef, Broadax ledge, at $2 50	250 00
75 cubic yards coarse sandstone boulders, third fall, at $2 50	187 50
12 cubic yards coarse sandstone, Holston rock, at $2	24 00
Capstan and fixtures to assist ascending boats	200 00
Total	1,036 50

THE SUCK, (15 miles below Chattanooga,)

is an obstruction caused by the contraction of the width of the river from 600 feet to 150 feet, and a change of depth from 47 feet in the basin, or that portion of the river above the rapids, to 25 feet at the head of the rapids, and seven feet at about the center of them, at low water, creating a current of six miles per hour, from the head to the foot of the rapids, a distance of 800 feet, and 10 miles per hour in the most rapid part.

The improvement demanded here will be the removal of the middle wall, (see sketch,) built for the purpose of making a canal on the left side of the river, deepening that portion of the river known as the canal, by blasting a length of 650 feet, width 30 feet, and depth two feet, which can be easily done, as the rock is a ferruginous sandstone, dipping about 50°, also removing a portion of the boulder bar, which is composed of deposit brought down by Suck creek.

In order to render the improvement of this boulder bar permanent, it will be necessary to turn Suck creek from its present mouth into its old bed, (shown in sketch,) where it now runs only at high water. The creek in that case would empty into the river 1,200 feet below its present mouth, and into a basin where no injury could result to navigation by the deposit of material brought down by the creek. This alteration in the bed of the creek can be made by forming a rough wall of the stone removed from the bed of the river and the boulder bar.

Suck creek is dry for six months in the year. During high water it has a width of 40 feet, average depth two feet, and a current of 12 miles an hour.

The rocks at the Suck are of a sandstone formation, most of which are cemented by oxide of iron, and vary from the hardness of limestone to that of soft sandstone. The following is an estimate for the improvement of the Suck:

1,250 cubic yards loose rock in middle wall, at 75 cents....	$937 50
1,444 cubic yards solid rock excavation deepening old canal, at $2 50.....	3,610 00
7,000 cubic yards loose rock excavation from boulder bar, at 50 cents.....	3,500 00
Total.....	8,047 50

BOILING POT, (19 miles below Chattanooga.)

The obstruction at this place is a high-water one altogether, and is caused by two points of land jutting into the river opposite each other, contracting the width of the river to 200 feet. Just below these points the width of the river increases suddenly, and at a distance of 300 feet from them it is 500 feet wide.

This sudden increase in width causes very dangerous eddies to form immediately below the points of land, making it extremely difficult for ascending boats to get through the narrowest portion of the channel, without being swept on to the point on the left bank, they having to cross from the right bank, and through the swiftest part of the current, for the purpose of getting a line on the left bank, to assist them in warping to a point above, from which they can ascend the river with the aid of steam alone. The current at high water, through the narrowest portion of the Boiling Pot, has a velocity of 15 miles an hour, and at low water three miles an hour.

The improvement demanded at this place is the excavation of the point of land on the right bank, the material excavated to be thrown into the eddy immediately below it, this will increase the water-way enough to stop the formation of this eddy and decrease the velocity of the current so that ascending boats can get through without warping. The estimate is as follows:

5,000 cubic yards hard sandstone excavation, at $1	$5,000 00

THE SKILLET, (20 miles from Chattanooga.)

At this place there is a large sand bar on the right side of the channel, causing the current to become very rapid at least 13 miles per hour for about 200 feet. Half a mile below this rapid portion of the current, the river becomes very wide and shallow, the water only being about 18 inches deep on top of the rocks. These rocks are detached from any reef or ledge, and are scattered irregularly about, averaging about one cubic yard each. The rocks removed would give a depth of 30 inches of water, to increase this a wing-dam will be required. The following is the estimate for proposed improvements:

Removing 25 isolated boulders, averaging one cubic yard each, 25 cubic yards, at $2 50	$62 50
Riprap wing-wall, 500 feet long, 6 feet wide, on top slopes 1½ to 1, 746 cubic yards, at $1 50	1,119 00
1 capstan and fixtures to enable ascending boats to warp through the swift portion of the current near the head of the sand-bar	200 00
Total	1,381 50

KELLY'S SHOALS, (28 miles from Chattanooga.)

The obstruction at this place is a shoal place of about 1,000 feet in length, bottom gravel on the line of the channel and to left of it with a very slow current for a place so shallow. The proposed improvement is a wing-dam on the right side, extending from near the foot of the shoal up the river and towards the right bank, the length of which will be 1,500 feet.

Estimate.

Riprap, 1,500 feet wing-dam to 6 feet wide on top, 4 feet deep, with slopes of 1½ to 1; 2,666 cubic yards, at $1 50	$3,999 00

LONG ISLAND, (63 miles from Chattanooga.)

This island is six miles long, and about half a mile wide at its widest part.

The Nashville and Chattanooga railroad crosses the river about the center of the island.

The steamboat channel is on the left side of the island, and in the channel are three reefs of flint rock, two above the railroad bridge and one below it, on which at low stage of the river there are but 18 inches of water.

About two-thirds of the entire water of the river passes down on the right side of the island, but the chute is so wide that the water is very shallow, and this channel is only available for purposes of navigation at high water.

If one-half of the water was taken from the right chute and thrown into the left, it is thought there will always be three feet of water on the reefs. To do this a wing-dam will be required at the head of the island 600 feet in length, with a retaining wall at the point where the wing-dam joins the island.

It is also suggested that one foot in depth, for a width 100 feet, be excavated from the three reefs in the left channel.

The estimate for the proposed improvement is as follows:

Riprap in wing-dam, 700 cubic yards, at $1 50	$1,050 00
Riprap in retaining wall, 225 cubic yards, at $1 50	330 00
Flint rock excavation at the three reefs, 450 cubic yards, at $2 50	1,125 00
Total	2,508 00

WIDOW'S BAR, (74 miles below Chattanooga.)

The length of this bar is about 4,000 feet. The depth of water at the lowest stage of the river varies from 14 to 24 inches. Velocity of current two miles per hour. The most shallow place is on a reef of rocks that extends across the river. Above the reef there is always plenty of water. On the reef at the lowest stage of the river there are only 14 inches of water; just below it there are 20 inches—with a gravel bottom—which increases to two feet near the mouth of Widow's creek, 4,000 feet below the reef. Below the mouth of the creek there is always plenty of water.

To the left of the point where the channel crosses the reef there is a large sand-bar, over which the water always flows.

The improvement suggested is, by building a wing-dam across the head of the bar 800 feet long and a wall 1,000 feet long from the lower end of the wing-dam parallel with the channel, thereby causing such an increase in the volume of water and velocity of the current as will cut out the gravel below the reef to a sufficient depth for all seasons of the year. The reef at the head of the shoal will also have to be excavated a depth of 30 inches and a width of 100 feet.

The estimate for which improvement is as follows:

Estimate.

Riprap in wing-dam, 2,920 cubic yards, at $1 50 per yard	$4,380 00
Riprap in wing-dam, dam to be 1,800 feet in length, 280 cubic yards, at 60 cents per yard	168 00
Solid rock excavation, 280 cubic yards, at $2 50 per yard	700 00
Total	5,248 00

LARKIN'S TOWHEAD, (112 miles below Chattanooga.)

At this place there are two sand-bars, one at the upper end of the towhead, and one on the right bank opposite, the channel running between them, with two feet of water at the lowest stage of the river, and a current of two miles an hour. The length of the shoal water is 1,200 feet. Above and below this shoal there is sufficient depth of water at all seasons of the year.

The improvement proposed at this place is by constructing a wing-dam and parallel wall combined, for a length of 1,200 feet, to be six feet wide on top, four feet deep, and the side slopes to be 1½ to 1.

The estimate for which is as follows:

Estimate.

Riprap, 2,133 cubic yards, at $1 50 per yard	$3,199 50

MINK CREEK SHOALS, (117 miles below Chattanooga.)

The obstruction at this place resembles the obstruction at Widow's bar, with the exception of there being no reef at this place.

The same plan and amount of wing-dam is suggested as at Widow's bar, viz:

Estimate.

Riprap wing-dam, 1,800 feet long, six feet wide on top, four feet deep, slopes 1½ to 1; 3,200 cubic yards, at $1 50 per yard	$4,800 00

BUCK ISLAND, (129 miles below Chattanooga.)

About a quarter of a mile above the head of the island the channel is very close to the left shore, with a low-water depth of 20 inches. From this point to a point one and a half mile below, there are three shoal places in the river, caused by large masses of rock scattered irregularly about in the channel. All these shoals have deep pools of water between them. The different shoals only average about 100 feet in length.

The improvement suggested is by a wing-dam at the upper shoal, and the removal of the rocks at the other three. The wing-dam will be 500 feet long, and have a cross-section area of 50 feet.

The estimate for the proposed improvement is as follows:

Estimate.

Riprap, 1,111 cubic yards, at $1 50 per yard	$1,666 50
Excavation of large masses of rock in island chute, 160 cubic yards, $2 50 per yard	400 00
Total	2,066 50

TOWN ISLAND, (133 miles below Chattanooga.)

At the head of this island there are a lot of boulders scattered about in the channel, which is close to the shore, with only 20 inches of water on them at the lowest stage of the river. If the rocks are removed there will be three feet of water in the channel at the lowest stage of the river down to Gunter's bar.

The estimate for removing the rock is as follows:

Estimate.

Boulders, averaging one and a half cubic yards each, 33 cubic yards, at $2 50 per yard	$57 50

GUNTER'S BAR, (135 miles below Chattanooga,)

is a rock reef, extending across the river near the lower end of Town island, on which at the lowest stage of the river there are but 10 inches of water.

To improve this place the reef will have to be excavated a depth of 33 inches, and 100 feet in width.

The following is the estimate of the proposed improvement:

Estimate.

Rock excavation, 407 cubic yards, at $2 50 per yard	$1,017 50

GUNTER'S REEF, (138 miles below Chattanooga,)

extends across the river with 20 inches of water upon it at the lowest stage of the river, and a current of about two miles an hour. This reef will have to be excavated for a depth of two feet, and 100 feet in width, to make the channel sufficiently large.

Estimate.

Rock excavation, 300 cubic yards, at $2 50 per yard $750 00

FLINT RIVER TOWHEAD, (157 miles below Chattanooga.)

Opposite this towhead, which is one mile in length, there are always three and a half feet water. At the lower end of the towhead there is a large sand-bar, the lower point of which is about in the center of the river.

The channel crosses from near the right bank to near the left bank, passing close to the lower point of the bar, a short distance below which and in the center of the river is another sand-bar, that at low water is dry. Between the two bars the water is only 25 inches deep at the lowest stage of the river; this depth continues for a very short distance, when the water again becomes deep enough at all stages of the river.

On the right side of the lower sand-bar there is a channel, in which, at the lowest stage of the river, there are 20 inches of water.

It is thought that if a wing-dam is built connecting the two sand-bars, thereby keeping all the water in the right-hand channel, the increased volume of water and velocity of current would cut out the channel to a sufficient depth, the bottom being composed of sand and fine gravel.

The length of wing-dam to do this would be 300 feet, six feet wide on top, four feet deep, and have side slopes of 1½ to 1.

Estimate.

Riprap in wing-dam, 533 cubic yards, at $1 50 per yard $799 50

WHITESBURG SHOALS AND REEFS, (166 miles from Chattanooga.)

The obstruction here commences at the head of Whitesburg island; that is three miles in length, and in this distance there are three places at which the water is only two feet deep at the lowest stage of the river. The bottom of the river at these places is composed of sand and fine gravel. Each of the shoals mentioned is 125 feet in length. Between them are natural pools in which there are from six to seven feet of water at the lowest stage of the river.

Just below the foot of the island there is another shoal of the same character and dimensions as those already mentioned. These shoals are caused by the great width of the river, it being 1,200 feet wide in the island chute.

In a distance of two miles from the foot of the island downwards, there are three other shoals on which there are only two feet of water at the lowest stage of the river. The first of these is situated three-fourths of a mile below the island, the second one and a half mile, and the third two miles.

The first is about 300 feet in length, and the obstruction is caused by boulders scattered irregularly about in the channel.

The second is about 60 feet in length, and consists of solid rock reef of flinty limestone extending across the river.

The third is about 30 feet in length, and is also a flinty limestone reef extending across the river.

The improvement suggested at the three shoals in the island chute, and the one just below the island, is by a wing-dam at each one of them to increase the depth of water and cut out the gravel bottom. This it is thought will give sufficient depth of water at all seasons of the year.

The aggregate length of these dams will be 1,600 feet, and have an average area of cross-section of 50 feet.

The improvement at the shoal three-fourths of a mile below the island will be excavation of the limestone reef, 100 feet in width.

At the shoal two miles below the island the improvement will also be excavation of the limestone reef, 100 feet in width.

The estimate of the proposed improvement is as follows:

Estimate.

Riprap in wing-dams, 2,963 cubic yards, at $1 50 per yard	$4,444 50
Removal of 25 boulders, averaging about one and a half yard each, at the shoal, three-fourths of a mile from the island, 37 cubic yards, at $2 per yard	74 00
Solid limestone excavation at the shoal, one and a half mile from the island, 333 cubic yards, at $2 50 per yard	832 50
Solid limestone excavation, at the shoal, two miles from the island, 167 cubic yards, at $2 50 per yard	417 50
Total	5,768 50

LIMESTONE SHOALS, (186 miles from Chattanooga.)

These shoals are about one mile in length, with an average velocity of current of two and a half miles an hour.

About 600 feet of the upper end of the shoals has a bottom composed of sand and fine gravel, then follows 2,600 feet of a rough rock bottom, having from 20 to 25 inches of water on the points of the rocks, with deep pools between them, at the lowest stage of the river. Below this rocky bottom, gravel and sand are again found for a length of about 2,000 feet, with a low-water depth of from 20 to 25 inches.

The improvement suggested is the excavation of the rock bottom. The estimate is as follows:

Estimate.

Limestone excavation, 3,000 cubic yards, at $2 50 per yard	$7,500 00

Estimated cost of removing obstructions from Chattanooga, Tennessee, to Decatur, Alabama.

Ross towhead, two and a half miles from Chattanooga	$3,004 00
Lookout shoals, five miles from Chattanooga	697 50
Burroughs bar, 11 miles from Chattanooga	2,020 00
Tumbling shoals, 13 miles from Chattanooga	1,036 50
The Suck, 15 miles from Chattanooga	8,047 50
Boiling Pot, 19 miles from Chattanooga	5,000 00
The Skillet, 20 miles from Chattanooga	1,381 50
Kelly's shoals, 28 miles from Chattanooga	3,999 00
Long island, 63 miles from Chattanooga	2,508 00
Widow's bar, 74 miles from Chattanooga	5,248 00

Larkin's towhead, 112 miles from Chattanooga	$3,199 50
Mink Creek shoals, 117 miles from Chattanooga	4,800 00
Buck island, 129 miles from Chattanooga	2,066 50
Town island, 133 miles from Chattanooga	57 50
Gunter's bar, 135 miles from Chattanooga	1,017 50
Gunter's reef, 138 miles from Chattanooga	750 00
Flint River towhead, 157 miles from Chattanooga	799 50
Whitesburg reef and shoals, 166 miles from Chattanooga	5,768 50
Limestone shoals, 186 miles from Chattanooga	7,500 00
Total	58,901 00

ELK RIVER SHOALS, (10 miles below Decatur.)

The obstructions at this point consist of a series of bars of a very hard limestone in strata of varying thickness. These break at right angles to the surface, over which the water rushes with a great but far from uniform velocity.

For the topographical features of these shoals reference is made to page 72 of this report, and also to the map of this part of the river on sheets Nos. 2 and 3 and profile on sheet No. 4.

The plan recommended for the improvement of navigation at this point consists of a canal from Brown's ferry, extending along the river bottom on the north side of the river to the foot of Sluice island, a distance of $10\frac{3}{10}$ miles; thence to the mouth of Elk river, a distance of 4,400 feet; the canal will be built in the bed of the river, between high embankments protected inside and out by slope walls. A sufficient space is left between the canal and the shore for the outlet of Poplar Creek slough.

Estimates of the cost of constructing this canal are appended. For greater convenience it has been divided into sections.

The estimate of the work is based upon the plan of making the bottom of the canal low enough to enable the river above to feed it at low water. It is believed that by the construction of a dam across the Tennessee river one mile below Brown's ferry, at the head of Cox's island, the water can be raised some seven feet, thus saving some 640,000 yards of rock excavation, and probably 500,000 yards of earth excavation, thus reducing the cost one-half.

If this plan were adopted, more masonry would be required at the upper end of the canal. On account of the limited time granted for the completion of the survey I was unable to obtain sufficient data for making an estimate of the work upon this basis, but I am decidedly of the opinion that the feasibility of this plan should be ascertained before the work of constructing the canal is commenced.

The dimensions of the canal for which the following estimates were made are, 100 feet width at bottom with a depth of water of six feet, and a slope in earth of one and a half foot horizontal to one vertical. The locks are to be 300 feet between the miter sills, and 70 feet in width.

Section No. 1, *length* 5,400 *feet.*

Grubbing and clearing 14.69 acres, at $35 per acre	$514 15
Clearing 5.78 acres, at $14 per acre	80 92
Earth excavation, 284,985 cubic yards, at 24 cents per cubic yard	68,396 40
Wet earth excavation, 3,300 cubic yards, at 40 cents per cubic yard	1,320 00

Rock excavation, 60,000 cubic yards, at $2 per cubic yard	$120,000 00
Puddling earth, 3,600 cubic yards, at 30 cents per cubic yard	1,080 00
Masonry laid in cement, 11,067 cubic yards, at $8 per cubic yard	88,536 00
Masonry dry, 1,800 cubic yards, at $2 per cubic yard	3,600 00
White-oak timber, (board measure,) 99,600 feet, at $95 per M feet	9,462 00
White-pine timber, (board measure,) 44,400 feet, at $50 per M feet	2,220 00
Cast iron, 30,000 pounds, at 12 cents per pound	3,600 00
Wrought iron, 50,000 pounds, at 18 cents per pound	9,000 00
Spikes and nails, 3,000 pounds, at 7 cents per pound	210 00
Snubbing posts, 320 lineal feet, at $1 per lineal foot	320 00
Fixtures for opening and closing gates of two locks, each $800	1,600 00
Total	309,939 47

Section No. 2, length 5,400 feet.

Grubbing and clearing 15.2 acres, at $35 per acre	$532 00
Clearing 6.1 acres, at $14 per acre	85 40
Earth excavation, 328,312 cubic yards, at 24 cents per cubic yard	78,794 88
Solid rock excavation, 60,000 cubic yards, at $2 per cubic yard	120,000 00
Puddling earth, 3,600 cubic yards, at 30 cents per cubic yard	1,080 00
Total	200,492 28

Section No. 3, length 5,300 feet.

Grubbing and clearing 13.8 acres, at $35 per acre	$483 00
Clearing 5.4 acres, at $14 per acre	75 60
Earth excavation, 321,756 cubic yards, at 24 cents per cubic yard	77,221 44
Solid rock excavation, 58,889 cubic yards, at $2 per cubic yard	117,778 00
Puddling earth, 3,533 cubic yards, at 30 cents per cubic yard	1,059 90
Total	196,617 94

Section No. 4, length 5,400 feet.

Grubbing and clearing 31 acres, at $35 per acre	$1,085 00
Clearing 12.4 acres, at $14 per acre	173 60
Earth excavation, 473,916 cubic yards, at 24 cents per cubic yard	113,739 84
Solid rock excavation, 70,000 cubic yards, at $2 per cubic yard	140,000 00
Puddling earth, 3,600 cubic yards, at 30 cents per cubic yard	1,080 00
Total	256,078 44

Section No. 5, length 5,400 feet.

Grubbing and clearing 31 acres, at $35 per acre	$1,085 00
Clearing 12.4 acres, at $14 per acre	173 60
Earth excavation, 250,284 cubic yards, at 24 cents per cubic yard	60,068 16
Solid rock excavation, 108,666 cubic yards, at $2 per cubic yard	217,332 00
Puddling earth, 3,600 cubic yards, at 30 cents per cubic yard	1,080 00
Total	279,738 76

Section No. 6, length 5,400 feet.

Grubbing and clearing 31 acres, at $35 per acre	$1,085 00
Clearing 12.4 acres, at $14 per acre	173 60
Earth excavation, 244,227 cubic yards, at 24 cents per cubic yard	58,614 48
Solid rock, 110,722 cubic yards, at $2 per cubic yard	221,444 00
Puddling earth, 3,600 cubic yards, at 30 cents per cubic yard	1,080 00
Total	282,397 08

Section No. 7, length 5,400 feet.

Grubbing and clearing 31 acres, at $35 per acre	$1,085 00
Clearing $12\frac{4}{10}$ acres, at $14 per acre	173 60
Earth excavation, 192,342 cubic yards, at 24 cents per yard	46,162 32
Solid rock excavation, 95,185 cubic yards, at $2 per yard	190,370 00
Puddling earth, 3,600 cubic yards, at 30 cents per yard	1,080 00
Masonry laid in cement, 2,924 cubic yards, at $8 per yard	23,392 00
Masonry laid dry, 400 cubic yards, at $2 per yard	800 00
White-oak timber, 35,884 feet, board measure, at $95 per M feet	3,408 98
White-pine timber, 14,448 feet, board measure, at $50 per M feet	722 00
Cast iron in lock No. 3, 15,000 pounds, at 12 cents per pound	1,800 00
Wrought iron in lock No. 3, 25,000 pounds, at 18 cents per pound	4,500 00
Spikes and nails in lock No. 3, 1,500 pounds, at 7 cents per pound	105 00
Snubbing posts, 160 lineal feet, at $1 per foot	160 00
Fixtures for opening and closing lock gates	800 00
Total	274,559 30

Section No. 8, length 5,300 feet.

Grubbing and clearing $30\frac{4}{10}$ acres, at $35 per acre	$1,064 00
Clearing $12\frac{2}{10}$ acres, at $14 per acre	170 80
Earth excavation, 121,946 cubic yards, at 24 cents per yard	29,267 80
Solid rock excavation, 86,110 cubic yards, at $2 per yard	172,220 00
Puddling earth, 3,533 cubic yards, at 30 cents per yard	1,059 90
Total	203,781 74

Section No. 9, length 5,300 feet.

Grubbing and clearing $30\frac{4}{10}$ acres, at $35 per acre	$1,064 00
Clearing $12\frac{3}{10}$ acres, at $14 per acre	170 80
Earth excavation, 98,415 cubic yards, at 24 cents per yard	23,619 60
Solid rock excavation, 42,926 cubic yards, at $2 per yard	85,852 00
Puddling earth, 3,533 cubic yards, at 30 cents per yard	1,059 90
Total	111,766 30

Section No. 10, length 5,400 feet.

Grubbing and clearing 31 acres, at $35 per acre	$1,085 00
Clearing $12\frac{4}{10}$ acres, at $14 per acre	173 60
Earth excavation, 119,671 cubic yards, at 24 cents per yard	28,721 04
Solid rock excavation, 3,148 cubic yards, at $2 per yard	6,296 00
Puddling earth, 3,600 cubic yards, at 30 cents per yard	1,080 64
Total	37,355 64

Section No. 11, length 5,700 feet.

Grubbing and clearing 4 acres, at $35 per acre	$140 00
Clearing $1\frac{5}{10}$ acre, at $14 per acre	21 00
Earth excavation, 313,200 cubic yards, at 24 cents per yard	75,168 00
Wet earth excavation, 15,000 cubic yards, at 40 cents per yard	6,000 00
Solid rock excavation, 9,300 cubic yards, at $2 50 per yard	23,250 00
Puddling earth, 1,500 cubic yards, at 30 cents per yard	450 00
Masonry laid in cement, 10,064 cubic yards, at $8 per yard	80,512 00
Masonry laid dry, 40,340 cubic yards, at $2 per yard	80,680 00
White-oak timber, 98,400 feet, board measure, at $95 per M feet	9,348 00
White-pine timber, 41,280 feet, board measure, at $50 per M feet	2,064 00
Cast iron in locks 4 and 5, 30,000 pounds, at 12 cents per pound	3,600 00
Wrought iron in locks 4 and 5, 50,000 pounds, at 18 cents per pound	9,000 00
Spikes and nails, 3,000 pounds, at 7 cents per pound	210 00
Snubbing posts, 320 lineal feet, at $1 per foot	320 00
Fixtures for opening and closing gates of locks Nos. 4 and 5—two, at $800 each	1,600 00
Total	292,363 00

Cost of sections 1 to 11, inclusive.

Total cost of section No. 1	$309,939 47
Total cost of section No. 2	200,492 28
Total cost of section No. 3	196,617 94
Total cost of section No. 4	256,078 44
Total cost of section No. 5	279,738 76
Total cost of section No. 6	282,397 08

Total cost of section No. 7	$274,559 30
Total cost of section No. 8	203,781 74
Total cost of section No. 9	111,766 30
Total cost of section No. 10	37,355 64
Total cost of section No. 11	292,363 00
Bailing and draining, including expense of coffer-dams	18,000 00
Total	2,463,089 95

RECAPITULATION.

Grubbing and clearing $263\frac{49}{100}$ acres, at $35 per acre	$9,222 15
Clearing $105\frac{18}{100}$ acres, at $14 per acre	1,472 52
Earth excavation, 2,749,055 cubic yards, at 24 cents per yard	659,773 20
Wet earth excavation, 18,300 cubic yards, at 40 cents per yard	7,320 00
Solid rock excavation, 695,946 cubic yards, at $2 per yard	1,391,292 00
Solid rock excavation, 9,300 cubic yards, at $2 50 per yard	23,250 00
Puddling earth, 37,299 cubic yards, at 30 cents per yard	11,189 70
Masonry laid in cement, 24,055 cubic yards, at $8 per yard	192,440 00
Masonry laid dry, 42,540 cubic yards, at $2 per yard	85,080 00
White-oak timber, 233,884 feet, board measure, at $95 per M feet	22,218 98
White-pine timber, 100,128 feet, board measure, at $50 per M feet	5,006 40
Cast iron, 75,000 pounds, at 12 cents per pound	9,000 00
Wrought iron, 125,000 pounds, at 18 cents per pound	22,500 00
Spikes and nails, 7,500 pounds, at 7 cents per pound	525 00
Snubbing posts, 800 lineal feet, at $1 per lineal foot	800 00
Fixtures for opening and closing gates of five locks, at $800 each	4,000 00
Bailing and draining, including expense of coffer-dams	18,000 00
Total	2,463,089 95

MUSCLE SHOALS, (28 miles below Decatur, and seven miles below the foot of the canal projected around the Elk River shoals.)

For a full description of the topographical features of these shoals reference is made to page 583 of this report, and also to the map upon sheet No. 5. The sketch upon this map illustrates the difficulty of navigation better than can be done in words. The plan recommended for the improvement of these shoals is the enlargement of the old canal, built in 1835 by the State of Alabama, for which estimates are hereunto appended.

The canal, as enlarged, is to be 100 feet wide on the bottom, with side slopes of one foot and a half horizontal to one foot vertical in earth. The locks are to be 300 feet between the miter sills, and 70 feet in width. The depth of water in the canal is to be six feet.

Estimate of the cost of enlarging old canal at Muscle shoals.

Grubbing and clearing 100 acres, at $30 per acre	$3,000 00
Deposit to be excavated from bed of canal, 383,300 cubic yards, at 24 cents per yard	91,992 00

Common earth excavation to enlarge the canal, 966,100 cubic yards, at 24 cents per yard	$231,864 00
Loose stone excavation in old retaining walls, 30,300 cubic yards, at 40 cents per yard	12,120 00
New retaining wall to be built of old material, 30,300 cubic yards, at $1 70 per yard	51,510 00
Retaining wall for which stone will be quarried, 7,300 cubic yards, at $2 per yard	14,600 00
26,532 cubic yards masonry in old locks, 4,250 of which can be used as it stands, 22,282 cubic yards, at $1 per yard	22,282 00
51,280 cubic yards masonry in new locks, 4,250 of which is old masonry, leaving 47,030 to be built, of which 22,282 will be built of old material—22,282 cubic yards, at $4 per yard	89,128 00
Masonry, for which stone will be quarried, 24,748 cubic yards, at $8 per yard	197,984 00
Dry wall, 7,550 cubic yards, at $4 50 per yard	33,975 00
White-oak timber, 587,700 feet, board measure, at $95 per M feet	55,831 50
White-oak timber, 622,300 feet, board measure, at $70 per M feet	43,561 00
White-pine timber, 370,600 feet, board measure, at $50 per M feet	18,530 00
Snubbing posts, 2,700 lineal feet, at $1 per foot	2,700 00
Cast iron, 255,000 pounds, at 12 cents per pound	30,600 00
Wrought iron, 425,000 pounds, at 18 cents per pound	76,500 00
Spikes and nails, 30,000 pounds, at 7 cents per pound	2,100 00
Fixtures for opening and closing 17 locks, at $8 each	13,600 00
Bailing and draining, including coffer-dams	10,000 00
Total	1,001,877 50

LITTLE MUSCLE SHOALS, (44½ miles below Decatur.)

These shoals are about four miles in length, ending one mile above Florence. The obstructions are similar to those at Big Muscle shoals, consisting of a series of rock reefs, over which the water flows with great velocity. There are about eight inches of water in the channel at the lowest stage of the river. No estimate was made of the cost of improving these shoals, the time of the party being so limited that nothing but a reconnoissance could be made. From this reconnoissance it was inferred that the best way of improving these shoals is by a canal about four and a half miles long, along the northern shore of the river around the shoals. This canal would be similar in its location to that around Muscle shoals, passing partly through alluvial bottoms and partly under bluffs, and its cost would approximate $500,000.

SEVEN MILE ISLAND, (four miles below Florence, Alabama.)

This island is about five miles in length. The right chute is about 500 feet wide at the head of the island, and has at low water a depth of only 20 inches.

The left or steamboat chute is 1,000 feet wide. Near the head of the island a reef makes out from the left bank and diminishes the steamboat *channel* at low water to a width of 60 feet. This reef, at low stage of

the river, has only eight inches of water upon it, and in the steamboat channel, at the end of the reef, but 25 inches. The bottom in the channel is of gravel. It is thought that taking 40 feet off of the end of the reef, and building a wing-dam at the head of the island, will give a sufficient depth of water all the year round. From this place to Buck island, in the same chute, there is always sufficient depth of water.

At the head of Buck island there is four feet of water at the lowest stage of the river, which decreases to two feet one mile below. This decrease is caused by water flowing off to the left through the opening between Buck island and a towhead at the foot of the island, and also through three other openings between towheads just below. The water can all be kept in the channel by a series of wing-dams connecting these towheads with each other and with Buck island. The aggregate length of these wing-dams will be 1,000 feet. Just below the last towheads there is always plenty of water.

The estimate for the proposed improvement of Seven Mile Island chute is as follows:

Estimate.

178 cubic yards flint-rock excavation, reef near head of island, at $2 50 per yard	$445 00
3,636 cubic yards riprap in wing-dam at head of island, length, 550 feet; depth, 7 feet; width on top, 15 feet; slope, 1½ to 1 foot, at $1 50 per yard	5,454 00
6,611 cubic yards riprap in four wing-dams connecting Buck island and towheads, total length 1,000 feet, cross-section as above, at $1 50 per yard	9,916 50
1,110 cubic yards riprap in five retaining walls, one at foot of each of the above dams, at $1 50 per yard	1,665 00
Total	17,480 50

COLBERT SHOALS TO BEE TREE SHOALS, INCLUSIVE.

At the head of Colbert shoals there is a rock reef of a tough, flinty nature, 30 feet long in the direction of the current and 600 feet wide, lying in the middle of the river, but not extending across it. At low water there is a depth of 24 inches on it. Between this reef and the head of Colbert island there are numerous large boulders scattered irregularly about in the channel, having 20 inches of water on them at the lowest stage of the river.

A large rock 10 feet square at the head of Colbert island, and another 600 feet above, (see sheet No 6,) are noted as being exceedingly dangerous obstructions to navigation. They lie directly in the steamboat channel, and are most dangerous at ordinary stage of the river, as at that time they produce but a very slight ripple in the surface of the water. At the lowest stage of the river there are but six inches of water on these two rocks, and alongside of them about three feet.

To make a channel of sufficient depth and width from the head of the shoals to the head of Colbert island, the excavation of the reef 150 feet wide and one and a half foot deep will be required; also the removal of the boulders, especially the two rocks noted on the map. (Sheet No. 6.)

From the head to the foot of Colbert island the channel is near the northern bank of the island, and has a low-water depth of 15 inches at the most shallow place, although for most of the distance the depth is

two feet. Width of channel, 150 feet. To secure a sufficient depth of water in this portion of the channel, it is suggested that a dam be built on the reef extending from Colbert island to Little Colbert island. The length of the dam would be 1,000 feet, 850 feet of which would be three feet deep, and 150 feet—the portion built across a gap in the reef—would be four and half feet deep. This plan, it is said, was contemplated by the State of Alabama many years ago, and large quantities of stone had been quarried on the left bank of the river for this purpose; but, fearing that the construction of this dam would make the current too rapid for ascending boats, the plan was abandoned.

This, it is thought, will not be the case, for fully one-half of the water in the river passes to the right of Colbert island, and being distributed over a large surface, (it is 1,800 feet from the head of the island to the right bank,) the dam proposed could hardly cause much increase in the velocity of the current, which is two and a half miles per hour at present at low water.

ROCK REEF.

A quarter of a mile below Colbert island a rock reef extends across the river 50 feet long in the direction of the current, with only 14 inches of water on it at the lowest stage of the river, in a channel 40 feet wide. This reef will have to be excavated a depth of two and half feet to give a good channel.

ROCK BAR SHOALS.

A quarter of a mile below rock reef is another reef of rocks extending across the river, with a channel 50 feet wide and a low-water depth of 20 inches. The reef is 40 feet long in the direction of the current.

This reef will have to be excavated a depth of two feet and a width of 100 feet to make a channel sufficiently wide and deep.

The same amount of work will also be required at the foot of Rock Bar shoals, where there is a similar reef. Between these reefs there are always from 30 to 40 inches of water.

BRUSH CREEK ISLAND.

Brush Creek island is rapidly forming above the point noted on the map, (sheet No. 6.) It is thought that 1,500 feet of the upper end of the island has been formed in the last 12 or 15 years.

River men say that the growth of the island by confining the water has had a tendency to deepen the channel.

BEE TREE SHOALS.

From the head of Bledsoe's island to the foot of the shoals at the mouth of Second creek there are about 20 large boulders scattered irregularly about in the channel, averaging about eight feet by four on top, with two feet of water on them at the lowest stage of the river. These removed, together with a few smaller ones, will give a channel three and a half feet deep at all seasons of the year.

Synopsis of distances and level notes from the head of Colbert shoals to the foot of Bee Tree shoals opposite the mouth of Second creek, the distance being measured on the line run on the right or northern bank of the river.

Distance from head to foot of Colbert shoals, 2.44 miles; total fall in surface of water, 10.65 feet; average fall per mile, 3.88 feet.

Distance from foot of Colbert shoals to the head of Bee Tree shoals, *3.60 miles;* fall in surface of water, 4.68 feet; average fall per mile, 1.30 *foot.*

Distance from head of Bee Tree shoals to foot of ditto, 1.59 mile; fall in surface of water, 5.59 feet; average fall per mile, 3.73 feet.

Total distance from head of Colbert shoals to foot of Bee Tree shoals, 7.93 miles; total fall in surface of water, 20.92 feet; average fall per mile, 2.638 feet.

Estimated cost of improving the Tennessee river from Colbert shoals to Bee Tree shoals, inclusive.

Rock excavation at the reef, one fourth of a mile above Colbert's island, 250 cubic yards, at $2 50 per yard	$625 00
Rock excavation, two large rocks above the head of Colbert's island, 25 cubic yards, at $2 50 per yard	62 50
Boulders above the head of Colbert's island, 2,000 cubic yards, at $1 50 per yard	3,000 00
Riprap in wing-dam, from Colbert to Little Colbert island, 2,384 cubic yards, at 75 cents per yard	1,788 00
Rock excavation at the reef one fourth of a mile below Colbert island, 460 cubic yards, at $2 50 per yard	1,150 00
Rock excavation at the foot of Rock Bar shoals, 300 cubic yards, at $2 50 per yard	750 00
Boulders in Bee Tree shoals, 50 cubic yards, at $2 per yard	100 00
Rock excavation at the head of Rock Bar shoals, 300 cubic yards, at $2 50 per yard	750 00
Total	8,225 50

BEAR CREEK SHOALS, (36 miles below Florence, Alabama.)

These shoals are formed by two gravel-bars, one on the left bank extending down the river for some distance, throwing the channel over near the right bank of the river, and one on the right bank below, throwing the channel towards the left bank, the channel passing between the two bars; at which place the water is the shallowest, there being but 30 inches at the lowest stage of the river.

The current flows in such a manner that a large quantity of water passes over the lower bar, which, if kept back and thrown into the channel between the two bars, would tend to cut out the gravel and make the channel as deep as is required. The improvement suggested to do this is a wing-dam built on the lower bar, extending from a point near the right bank across the bar for a distance of 400 feet. The estimate is as follows:

Estimate.

Riprap wing-dam, 400 feet long, four feet deep, six feet wide on top, and side slopes of one and a half to one foot—711 cubic yards, at $1 50 per yard	$1,066 50

BIG BEND SHOALS, (56 miles below Florence, Alabama.)

The obstruction at this place is caused by several large boulders scattered irregularly about in the channel, for a length up and down the river of less than 100 feet.

There being at the lowest stages of the river 30 inches of water over these boulders, all that is required to make a channel of sufficent depth is the removal of the boulders, amounting to a sum equal to 150 cubic yards, at $2 per cubic yard. Total cost, $300.

Below Waterloo there are several small obstructions, regarded as difficulties only by pilots not familiar with the channel of the lower Tennessee river.

Big Bend, 56 miles below Florence, the only one that offers any difficulty, is produced by several large boulders scattered irregularly about for a length in the direction of the current of 100 feet. At low water there are 30 inches on these rocks; current three miles per hour; channel 200 feet wide.

The following list embraces the few remaining points sometimes spoken of by steamboat men as small difficulties:

Duck River shoals—produced by a sand-bar; depth of water five feet; current four miles per hour.

Duck River suck—an abrupt bend in the channel, produced by a few large rocks with four feet water upon them at low stage; current two and a half miles per hour.

Blood River island—channel made tortuous by a large boulder in the center of the channel. Rock measures about 20 cubic yards; admits of easy removal, and would give a deep channel at all times.

Penticost-towhead—difficulty produced by a few rocks between towhead and Aurora landing, causing boats to go considerably out of their way in landing at Aurora, in order to avoid them.

Johnsonville—difficulty caused by the wrong position of the draw of the Northwestern Railroad bridge. Draw in second west span (seven spans) with only 28 inches, while under other spans there are eight feet.

Green Bottom bar—channel contracted by a series of sand-bars near left bank; channel 300 feet wide, one-half mile long; not less than four feet of water; current three miles per hour.

Total estimated cost of improvements to be made in Tennessee river, from Chattanooga to Paducah.

Obstructions from Chattanooga to Decatur	$58,901 00
Elk River Shoals canal	2,463,089 95
Enlargement of Muscle Shoals canal	1,001,877 50
Little Muscle Shoals canal	500,000 00
Seven-mile island	17,480 50
Colbert shoals to Bee Tree shoals, (inclusive)	8,225 50
Bear Creek shoals	1,066 50
Big Bend shoals	300 00
Total	4,050,940 95

THE PHYSICAL CHARACTER OF THE TENNESSEE RIVER AND ITS VALLEY ABOVE MUSCLE SHOALS.

The Tennessee river has three marked general topographical features, determined by the mountainous, rolling, and level region through which it passes. A general description, therefore, of the topographical and geological character of the river at any point will apply to every part of the river lying in the same topographical system.

Similarity between Cumberland and Tennessee rivers.—An examination of the map of the United States will reveal a great similarity in the courses of the Tennessee and Cumberland rivers. They rise in the same range of mountains, flow to some extent parallel and empty into the same stream, with their mouths only a few miles apart; but here

their similarity ceases. The Cumberland, after making its way through the mountains, flows for hundreds of miles through a chasm in limestone several hundred feet below the general surface of the rolling country, whilst the Tennessee, after issuing from the mountains, enters a broad valley, known as the Tennessee valley, the river banks becoming low and the surface of the country level or gently undulating.

Geological relation of the two rivers.—This difference between the two rivers is observed to mark the connection between the geological and topographical features of the two streams. So rapidly do the silurian rocks which furnish the Cumberland topography sink towards the south, that they scarcely reach the Tennessee in more than one or two points. The transition from this system of rocks to the carboniferous produces a corresponding change in the topography, the harsh lines of one order blending with the agreeable outline and graceful contours of the other.

Tennessee river at Chattanooga.—In the vicinity of Chattanooga the Tennessee river may be considered as finally breaking through the Cumberland mountains. Above Chattanooga it is flanked on the right bank by Stringer's and Waldron's ridges and on the left by Missionary ridge. Unopposed in its progress so far, it forms a fair navigable stream; but when Lookout mountain presents itself as a barrier, opposing the tendency of the river to flow south and deflecting it against Waldron's ridge, numerous obstructions result, embracing Ross towhead, Lookout shoals, Burroughs's bar, Tumbling shoals, the Suck, the Pot, the Skillet, and Kelly's shoals.

High water at Chattanooga—Damming of water at Stringer's ridge.—At Chattanooga the river at low water is 1,200 feet wide, eight feet deep in the channel; velocity of current two miles per hour. The right bank is 25 feet higher, between which and Stringer's ridge there is a rich bottom three-quarters of a mile wide; the left bank is 60 feet high and the country back of it diversified with hill and plain. A bold bluff of limestone shows itself on the left bank, underlaid by flint, which forms the bed of the river. At this point the difference between low and ordinary high water is 40 feet; in the spring of 1867 it was 60 feet, or 35 feet above the bottom land on the right bank. It is the opinion of some river men that this great difference is not produced entirely by local causes, but is the result of the damming of the waters by the mountains at the Suck. It is more probable that this backwater, if there is any, at high stages is produced by the resistance to the flow of water at the sharp bend of the river at Lookout mountain, causing the river to dam against Stringer's ridge.

River between Chattanooga and Tumbling shoals.—The river and obstructions at Ross towhead, Lookout shoals, Burroughs's bar, are the same in their general character: mountains on one bank rising almost immediately from the river, and bottom land on the other bank from one-half to three-quarters of a mile wide, and from 25 to 30 feet above low water. These bottom lands are composed of a dark, rich vegetable soil of varying depth, sometimes as much as eight feet, underlaid by a stratum of red clay and sand, and under this lies a limestone intermixed with flint, which forms the bed of the river at these several obstructions; there are, however, at Burroughs's bar, about two feet of gravel on this rock, the bar being formed by William's island, three miles long and three-quarters of a mile wide.

A dense cane growth is found along the river banks of the bottom lands; and on the mountain sides are varieties of timber, principally oak, hickory, walnut, and beech.

At low water, least depth of water at Ross towhead is 10 inches; at Lookout shoals, 24 inches; Burroughs's bar, 24 inches. Average depth

channel between Ross towhead and Lookout shoals, 10 feet; between ookout shoals and Burroughs's bar, nine feet; velocity of current in ese parts four miles per hour.

At Tumbling shoals, Waldron's ridge on the right and Raccoon moun- in on the left, with their summits about 800 feet above the river, con- act its width to 400 feet. The banks are 20 feet high; narrow bottom nds on either side rapidly ascending towards the mountains. The ver bed for a half mile is obstructed with large sandstone rocks, some holly and others partly submerged, and weighing from 100 pounds to tons, this being the only point below Chattanooga where the obstruc- ons are formed by sandstone. The greatest velocity of current at is point is 10 miles per hour; least depth, three feet; width of channel, feet; very crooked and difficult to navigate. The fall of the shoals four feet in one-third of a mile; total fall from Chattanooga to the wer end of Tumbling shoals, 14½ feet in 12 miles.

Between Tumbling shoals and the Skillet the river flows through a ere mountain gap, the width of the river not exceeding 500 feet; the ttom lands disappear or are found at the mouths of mountain ravines few acres in extent. In consequence of the narrowness of the river d the material washed down from the mountain into the river by ick creek, emptying into the river at right angles to its course, the ick obstruction has been formed. It is 100 feet wide in its narrowest rt; 400 hundred long; from 7 to 15 feet deep at low water; has a rrent of 10 miles per hour in its swiftest part. The bed of the ream is covered with large boulders, which do not seem to change their sition although exposed to so swift a current. There is a large boul r-bar some acres in extent to the right bank, and some futile attempts ve been made on the left bank towards improvement, but have only ded to the difficulties.

The Suck—The Pot.—From the Suck to Tumbling shoals above, stance of three miles, there are from 10 to 40 feet of water; below the ick the river is deep and narrow; current one and one-half mile per ur; bank 25 feet high; slope 45 degrees, and composed of gravel and se rock. The mountain slope is 150 feet from the bank, and this stance diminishes until the near approach of the mountain slopes pro- ced the Pot, the last important impediment to navigation between own's ferry, 180 miles below, and Knoxville, 220 miles above.

General view of obstructions between Chattanooga and the Pot.—From is point to Chattanooga the river is made up of a succession of basin d shoals, the total length of obstructions being two miles; navigable ter 17 miles, with reference to low water. It may be noted here that e bed of the river in the Chattanooga chain of obstructions is a silic us limestone, passing through various gradations of hardness. In me places it is an impure limestone, passing into a coarse, cherty rock d at others it becomes hornstone, having the luster and fracture of t, with numerous imbedded nodules of quartz variously colored.

The river leaves the mountains.—The river may be considered as ending re its mountain career. The mountain ridges gradually recede from e river, giving place to fertile bottom lands, until the river reaches quatchie valley, where the bottom becomes a valley. Reefs, shoals d eddies disappear from the river, and the only obstructions that esent themselves are a few sand and gravel bars, or some rock that lds to slight work.

Plains of Alabama.—At Bridgeport, Alabama, the river enters the ins of Alabama. For 56 miles its course is nearly southwest, with vide level region on its right and sand mountains on its left.

River between Bridgeport and Guntersville—Sand mountain—Fertile bottom lands.—Throughout this distance the river is very uniform in its character, having a width of 1,500 feet, and with the exception of Widow's bar and Guntersville reef, with 12 and 14 inches of water respectively, there is an average depth of six feet. The bed of the river consists of mountain limestone; bank from 25 to 30 feet above low water; easy slope and covered with vegetation. Sand mountain, sometimes called Raccoon mountain, lies three miles to the left of the river at Bridgeport and six miles to the left at Widow's bar. This ridge runs nearly south, and as the course of the river is southwest, the country spreads out into a broad valley some 20 miles below Widow's bar. On the right bank the bottom land is from one and a half to two miles wide; beyond this is the upland, 20 to 25 feet higher than the bottoms. These bottom lands and the few large islands in the river have the richest alluvial soil, subject to four feet overflow; which, however, is not considered objectionable, as the uplands furnish elevated sites for residences, and the overflow annually enriches the soil.

River and valley below Guntersville.—At Guntersville the river turns almost at right angles to its former course and flows northwest. The valley below this point is one of denudation, or scooped out in the horizontal strata of the carboniferous rocks. Near Guntersville a low ridge of mountains is cut through by the river, exposing carboniferous limestone about 100 feet high; this is the last spur of the Cumberland mountains which the Tennessee river meets in its course to the Ohio. Viewing the river between Guntersville and Bridgeport as the arc of a circle, this ridge would be the chord, passing by Huntsville, intersecting the river near Guntersville, and onward south.

Changes on the face of the country.—One notable feature of this portion is the absence of vegetation on the slopes of the river banks, indicating the sandy character of the soil. The country having been once in a high state of cultivation, but little timber is seen immediately on the river. The strong red soil, so characteristic of North Alabama, the numerous water courses, and the undulating surface of the country, once justly entitled it to be called the garden spot of the south.

From Bridgeport to Decatur the fall in the river does not exceed perhaps 20 feet in the distance of 100 miles, there being only two places, Guntersville and Widow's bar, where the river is extremely shallow at low water; with this slight fall the current is always moderate, in few places greater than three miles per hour at high water, when the river is 30 feet deep.

From Decatur to Brown's ferry, the head of the lower series of obstructions, a distance of 12 miles, is found the best part of the river lying between Muscle shoals and the head of the river. The average depth is nine feet at low water, least depth three and a half feet; width from 1,500 to 1,800 feet; current one and a half mile per hour, and navigable in any part, even in low water. The river here resembles a lake; this character, and the proximity of a large slough and Swan lake, would favor the opinion that the channel once washed against the low hills of the uplands, three miles east of Decatur. The force of the current is now directed against the Decatur bank; and as this is composed of limestone and a compact mass of gravel, cemented by oxide of iron, the present channel may be regarded as stable.

Below Decatur, and to the left of the river, the fertile valley of Courtland spreads out 15 or 20 miles from the river to the base of the terraced sand mountains of Alabama. On the right of the river are the low marshy bottoms, three miles wide to the uplands, diminishing at Brown's ferry to a few hundred feet.

As Brown's ferry may be regarded as the head of the lower group of shoals, a cursory view of the river and its valley between this point and Bridgeport will enable one to appreciate better the adaptation of the river as a great commercial highway, and the alluring advantages and beautiful natural wealth of the country.

From Brown's ferry a majestic river, broad, deep, and with gentle current at all times, is seen stretching for a hundred miles above through a valley abounding in the latent elements of prosperity; a river which in this distance is seldom seen to bear on its bosom a pellicle of ice, and a country whose climate is so genial that wheat is ripe for harvest by the time green blades in the northwestern States emerge from the snow. Yet, with this favorable combination of natural resources, the valley languishes for want of a cheap transportation to market, and this portion of the river for purposes of constant and certain navigation, is as sealed as though the river had no outlet to the Mississippi valley. Such are the effects, not the magnitude, of the obstructions in Chattanooga mountains and at Muscle shoals.

Between Brown's ferry and Second creek below, a distance of 70 miles, there is a chain of obstructions more or less serious, the difficulties culminating at Big Muscle shoals, and dividing the length of the river into what might be called the upper and lower Tennessee. This chain may be divided into Elk River, Big Muscle, Colbert, and Bee Tree shoals, the latter being understood by many as included in Colbert shoals.

Cox's island—length five miles, greatest width one mile—the beginning of this chain, divides the river into two chutes 1,500 feet wide, each, the left chute conveying two-thirds of the water in the river. From 30 feet at Brown's ferry, low water, the depth diminishes to six feet in channel. At Cox's island the current is one mile per hour. From this point to Milton's bluff, seven miles below, the channel is from 50 to 150 feet wide and 18 inches deep in the shallowest places.

Opposite Elk river mouth and across the river there is a shoal, Big Jump, on which there are but six inches of water. This low-water channel is very winding and intricate, and consequently dangerous, and at lowest stage of water altogether impracticable. From head of Cox's island to the foot of Big Jump the aggregate fall is 25 feet. The bed of the river is composed of a series of bars of a very hard mountain limestone, in strata of various thickness, usually dipping in the direction of the current. These break at right angles to the surface, over which the water rushes with a great but far from uniform velocity.

From Brown's ferry to mouth of Elk river, a low, flat alluvial bottom, subject to inundation, extends on the right bank. In some places it is a mile wide, and is only interrupted at Potter's bluff, half a mile above Elk river, which rises from the water's edge. The limestone bluff extends up the bottom as far as Poplar Creek slough, where it is only a few feet high.

On the left bank from head of Cox's island to Milton's bluff, 14 miles below, the bottom varies in width from two miles at the head of the island to nothing at Milton's bluff, which is a precipitous wall of mountain limestone springing from the river. Except at these places, viz: Lamb's ferry, at the head of Muscle shoals, and at the mouth of Town creek, where the short, flat bottoms intervene on an extent together of four miles, the left bank of the river from Lamb's ferry to Florence is high, rocky, generally abrupt; distance 23 miles. The river between Elk river and Muscle shoals, with the exception of Nance shoals, a minor impediment, is always in a fair navigable condition. At low water its least depth is three feet, from 1,500 to 1,800 feet wide, and a very slow

current. Five miles below Elk river occurs the obstruction which, more than all others combined, has crippled the navigation of the Tennessee river. The channel as far back as Bridgeport has been in carboniferous limestone, sometimes chert, and interstratified with flint; especially at Elk river shoals. This formation now thins out, and the underlying rock appears which produces Muscle shoals. It is the lowest of the silicious formation and lies at the bottom of the carboniferous rock. It is of a dark color, and flinty structure and hardness; this quality has enabled it to withstand the abrasion of the water, and has compelled the river to expand suddenly from 1,500 feet to one, two, and three miles in width, making up in width what it lacks in depth for the accommodation of its waters.

Big Muscle shoals are 15 miles long, with a fall of 85 feet in this distance. Owing to the horizontal position of the strata and their thinness, being only from one to three feet thick, there is a succession of cascades or steps (see sketch on map of Muscle shoals) in the whole extent of the shoals, corresponding to the thickness; and the direction of the steps across the river is also that of the joints that intersect the strata.

The most favorable chutes are found where the strata are thinnest, and consequently where there is least fall of water. There are sixty islands, averaging two acres in extent, and about as many towheads or patches of vegetation scattered in the shoals. There is no channel at low water in this part of the river; in many places a person can walk across the river without wetting his feet, and the lightest flat-boat cannot descend the shoals without being assisted in many places on rollers.

On the right bank the upland makes toward the river at the head of the shoals, leaving a narrow bottom a few hundred feet wide extending to Shoal creek, 20 miles below, upon which the old canal is built.

There is a vertical escarpment, of the same rock as that in the bed of the river, extending from Second creek to Bainbridge, and gradually increasing from a few feet in thickness to 100 feet at the lower end of the canal; this may be taken as the total thickness of the strata in the bed of the shoals.

The difference between high and low water at the shoals is only five feet, corresponding to a 50-feet rise at Chattanooga; velocity of currentat high stage from five to 10 miles per hour; bottom lands overflowed only in very low places.

Second creek, Blue Water creek, and Shoal creek, on the north bank, and Livingston creek, Clear creek, Town creek, and Big Nance creek, on the south bank, are large streams, with fertile bottom lands at their mouths. They drain some of the richest portions of the Tennessee valley, and as they are much depressed below the general surface of the country, might admit of slackwater improvement when the interests of the country demand it.

Between Big Muscle and Little Muscle shoals there are three miles of good water, due to the presence of limestone which forms the bed of the river; but the silicious rock of the big shoals with its strongly marked stratification again appears at the end of the three miles, producing Little Muscle shoals, some three miles long. Though not of the same magnitude as the upper shoals, yet navigation upon them at low water is impracticable, there being only 10 inches at low water, though in many parts the water is three feet deep.

At Florence stratified limestone again sets in and forms a perpendicular bluff on the left bank for seven miles below. Beyond these bluffs the Tuscumbia and Courtland plains are reached by gentle acclivity.

On the right bank are extensive river bottoms, in some places two miles wide, bounded by rough hills of the north uplands.

Between Florence and Waterloo, 34 miles, occurs only one serious obstruction, Colbert shoals; the others, Little Buck shoals and Bee Tree, admitting of easy removal, as they are formed by small sand and gravel bars.

At Colbert shoals the bed of the river is composed of cherty limestone, stratified; it is flinty, tough, and difficult to work; breaking nearly always at right angles to the surface of the rock.

The layers are thick; dip slightly in the direction of the current, and in some places they break into steps similar to but not so frequently as the strata do at Muscle shoals. These few reefs, together with some sand and gravel bars and islands, constitute the obstructions. The river at this point is a mile wide, least depth 10 inches, upon a rock 50 feet long in the direction of the current; with this exception there are 20 inches of water on the shoals. As there is ample water below Colbert shoals, with the exception of Bee-tree, where only a few large isolated rocks make it unsafe to boats at low water, this general view need not be extended.

To arrive at a correct idea of the comparative difficulties of the navigation of the different parts of the Tennessee river, the following points may be recapitulated:

Relative and absolute fall in the river from Chattanooga to Waterloo, 242 miles.

	Distance, miles.	Fall, feet.
Chattanooga to the Suck	15	18
Suck to Bridgeport	45	10
Bridgeport to Brown's ferry	125	21
Brown's ferry to Elk river	11	26
Elk river to head of Muscle shoals	5	2
Head of Muscle shoals to Bainbridge	17	85
Bainbridge to Florence	7	23
Florence to head of Colbert shoals	11	3
Head of Colbert shoals to Waterloo	6	21

A total fall of little over 200 feet in 242 miles, more than one-half of which is concentrated at Big and Little Muscle shoals, in a distance of only 22 miles. Now, if with this idea of the relative magnitude of these shoals and the other obstructions is mentioned the fact that during only from three to four weeks in the year can boats pass over Muscle and Elk river shoals, and then with danger, while steamboats of three feet draught can navigate from head of Elk river shoals to Knoxville, 300 miles above, nine months in the year, the shoals in the vicinity of Chattanooga cease to be obstructions in this point of view.

Nor is navigation limited to Knoxville. For six months in the year boats of two feet draught can ascend 125 miles above Knoxville, up the Holston river; 100 miles up the Little Tennessee river; 150 miles up the Chinch river; 75 miles up the Hiawassee; 125 miles up the French Broad river; and 50 miles up Towels river; making 625 miles of tributary navigation. If to this be added the first 300 miles, there are 925 miles of six months and 300 miles of nine months' navigation, with only three weeks precarious outlet at Muscle shoals to the lower Tennessee and

Mississippi valley, from a region whose draining into the Tennessee embraces 15,000 square miles.

These figures include only the extent of natural navigation. But these six tributaries having narrow or no bottom lands, and walled in by precipitous bluffs, would admit of easy slack-water improvement, their fall being no greater than that of the Tennessee at Muscle shoals. By this means navigation on the Holston could be extended 60 additional miles to Bristol and Virginia salt works, 160 miles above Knoxville; on the Clinch river, 50 miles above natural navigation, or 200 miles above its mouth; on the Hiawassee river, 100 additional miles, or 175 above its mouth; on the French Broad river, 100 additional miles, which would extend its navigation to Asheville, North Carolina—its present head of navigation being at Dandridge, Tennessee; on Towels river, 50 additional miles. Total slack-water navigation in the mountains, 360 miles, making a total navigation above Muscle shoals of nearly 1,300 miles.

Besides the above facts appertaining strictly to the Tennessee river and its valley, there are others continental in their character, and deserve some consideration in connection with this general description of the Tennessee river.

In examining, on the map, the anomalous course of the Tennessee river, it is observed to approach very closely to the rivers of the Gulf slope. At Guntersville, the distance between the Tennessee and Coosa rivers at Gadsden is only 45 miles. As the obstructions of the Tennessee islands below Gadsden, on the Coosa, will be surmounted in time, it becomes an interesting question as to whether a water connection by canal can be made between the Tennessee and Coosa rivers at Guntersville and Gadsden, thus giving a direct water communication from the Tennessee valley to the Gulf.

The topography of this part of the country indicates the feasibility of this work, and from the records of the Gadsden and Guntersville railroad survey sufficient data might be obtained to determine the magnitude of the undertaking; but the commercial advantages that would attend the construction of this work are so great as to demand an examination of the country with this special view.

Another locality inviting attention is that between Asheville, North Carolina, mentioned as the head of future slack-water navigation on the French Broad, and the Catawba river in North Carolina, emptying into the Atlantic ocean. This distance is about 40 miles. No opinion can yet be advanced as to the practicability of this enterprise, but it is entitled to notice in this bird's-eye view of the Tennessee valley.

It is by such a broad and comprehensive view of the subject that is obtained a proper estimate of the interests involved in the removal of the difficulties to navigation at Muscle shoals. These interests are not confined to the Tennessee valley, but may in time be made to affect the Gulf and Atlantic coasts, for the impetus which would be given to commerce and trade in the Tennessee valley by this improvement would demand the slack-water improvement of its tributaries pointed out, and these in time, as the country became fully developed, would lead to the consummation of a direct connection by water of the Tennessee valley and the waters of the Atlantic and Gulf.

Such are the immediate and distant results which must attend the removal of the obstructions at Muscle shoals. But as it is, the Tennessee river for purposes of commerce is a great national artery severed at Muscle shoals. To restore a healthy circulation to trade, and vitality to a great section of the United States, wasting away under influences that can be counteracted only by bringing it in contact with the

moving commercial world, is within the easy accomplishment of the engineer, and needs only a careful study of the Tennessee river, and the vast hydrographic system of which it is the trunk, to perceive the insignificance of the time and means required for this work when compared with the gigantic results to be achieved.

SOME STATISTICS AND OTHER FACTS SHOWING THE UTILITY OF THE IMPROVEMENTS AT MUSCLE SHOALS.

According to the statistics of the census of 1860, the proportion of improved acres in the Tennessee valley, above Muscle shoals, was 6,700,000; unimproved, 2,900,000. The great body of this improved land lies adjacent to the river, and therefore represents the finest lands in the south. On this territory there was a population not greater than 500,000, or averaging only 33 persons to the square mile. The proportion of the returns for this portion of the valley are estimated in round numbers as follows:

	Number.
Horses, asses, and oxen	558,000
Hogs	1,173,000
Wheat, (bushels)	2,729,000
Corn, (bushels)	26,045,000
Oats and rye, (bushels)	1,261,000
Tobacco, (pounds)	26,724,000
Cotton, (bales)	180,000
Sheep	386,000
Wool, (pounds)	702,000
Irish and sweet potatoes, (bushels)	1,898,000
Hay, (tons)	70,000
Butter, (pounds)	5,008,000

This was at a time when the only facilities to market, as at present, were afforded by three railroads, and when the whole energies of the farmer were devoted to the culture of cotton; the expense of getting his grain to market prohibited him from raising cereals to any greater extent than that of home consumption.

The culture of cotton having been generally abandoned as unprofitable, other products, especially wheat and corn, must increase proportionally, and will require a far greater and cheaper outlet than that now afforded. That these will in time be the staples, and that vast quantities of other cereals and stock will be raised for market, may be inferred from the well-known fact that the soil and climate of the Tennessee valley are peculiarly adapted to the culture of grain.

Wheat matures six weeks earlier in north Alabama than in the northwestern States, and brings the highest price in the New York market. While the northwestern farmer has a rigorous winter to contend with, which compels him to house and feed his stock for six months in the year, stock can graze all winter in north Alabama, thus saving the farmer the labor of providing for it. The northwestern farmer, moreover, has only six months in the year in which the weather will permit him to provide for his wants in winter, while there is hardly a day in the year when the north Alabama farmer cannot till his ground.

These advantages of this section of the country over the northwest must have their weight, and when it is more generally known that the climate invites the farmer here which permits the Malaga grape, the fig and pomegranate to flourish in the open air in the vicinity of Chat-

tanooga and Huntsville—a climate which has neither the rigorous winters of the north, nor the feverish summers of the extreme south—immigration must be turned to the Tennessee valley. Its mild, uniform climate, fertile soil, pure air and abundant water, its educational and social advantages, and a liberal policy to be pursued by large landholders, are points not to be disregarded by those seeking homes.

The mineral wealth on the tributaries of the Tennessee river is no less than the agricultural resources of its valley. This region is fast becoming known to the people of the country as one of the richest sections in mineral deposits in the United States, whilst its merits as an agricultural and stock-growing country are illustrated by the fact that from it both armies subsisted for nearly two years during the late war.

The coal deposits of Hamilton and Rome counties, Tennessee, are enormous, and the coal is of an excellent quality; but that produced from the mines of Anderson county has been developed only recently and is transported by rail to Memphis, Atlanta, Augusta, Macon, and other cities of the south, where it is pronounced equal to the best Pittsburg coal for all purposes.

The opening of the river would develop the coal trade to an immense extent, by enabling it to be furnished to distant points at half its present price, and with it would stimulate the manufacture and exportation of iron, zinc, and copper, of which vast quantities are found in this section of the State.

According to the census of 1860, the amount of coal mined in Tennessee was 3,474,100 tons, full three-fourths of which were from the upper Tennessee. At Florence, Alabama, this trade would in time receive another feeder from the mountains of Alabama, 30 miles from the river, where the coal is of a superior quality.

With the opening of the Tennessee river at Muscle shoals, Emory river coal could be delivered at Decatur for 24 cents per bushel, at Paducah for 27 cents, without any interruption to the trade from ice.

Wheat could be transported to New Orleans for 20 cents per bushel, and thence to New York for 12 cents per bushel, making 32 cents from the Tennessee valley to New York, whilst freights from Dubuque, Iowa, by rail to New York is 68 cents, which the western farmers are compelled now to pay.

If, eventually, there should be a connection between the Tennessee and Coosa rivers by canal, grain could be transported from the valley to Mobile for 12 cents per bushel, reducing the distance of water carriage 800 miles, and the freight to New York to 24 cents.

Further evidence of the national benefits which would result from the improvement contemplated need not be multiplied.

In whatever light the opening of the Tennessee river is viewed, whether as a means of developing the material prosperity of the valley or as a means of strengthening the bond of union between north and south by promoting intercourse between them, the subject is one of great moment, and recommends itself to the serious attention of the capitalist and statesmen.

THE ONLY IMPROVEMENT NOW ABSOLUTELY DEMANDED.

After careful consideration of the subject I am forced to the conclusion that the only appropriation now absolutely demanded to open the Tennessee river for nine months in the year, is one sufficient to build a canal from Brown's ferry to the mouth of Elk river, a distance of 11 miles; to repair the one already built from Campbell's ferry to Lamb's

ferry, around Muscle shoals; and to remove or overcome the obstructions at Little Muscle and Colbert shoals. All the other impediments to navigation are not insurmountable at most stages of the water as they at present exist, but these shoals are. I would therefore call your especial attention to the description of Elk river, Muscle, Little Muscle, and Colbert shoals, and to the plans and estimates for their improvement.

PREVIOUS APPROPRIATIONS AND EXPENDITURES.

The obstacles to navigation between Brown's ferry, 35 5-8 miles above Florence, Alabama, and Waterloo, about 30 miles below it, consisting of Elk river, Muscle, Little Muscle, and Colbert shoals, are the only formidable ones in the river, and this section of the river has been repeatedly surveyed with a view to overcoming them, the first survey having been made by a board of United States engineers in 1828.

The topographical features of these obstructions as noted in the survey just concluded have already been described in their appropriate place, as had also the plans now proposed for overcoming them.

In 1832 the board of internal improvement projected a plan to overcome them, based upon the surveys of 1828, and those made in the three subsequent years, consisting of a canal from the head of the rapids next below Brown's ferry, thence following the course of Sluice island for six or seven miles, to descend to a basin to be formed at the mouth of Elk river, for the accommodation of that stream. A dam across the Tennessee was to effect this object. From the basin at Elk river the canal, following the northern shore of the river, was to be formed on the alluvial bottoms where the cliffs jut into it. The passage of all the streams except Shoal creek was to be effected by dams. Shoal creek was to be crossed by an aqueduct.

A basin to be formed at Campbell's ferry by a dam across the Tennessee was to receive the canal at that place, and the lower levels were to be carried thence along the northern shore, chiefly under the cliffs, to the deep water at Florence. The estimated cost of the work, assuming a breadth of 60 feet for the trunk of the canal, was $1,388,102 54, and for a breadth of 70 feet, $1,424,455 81, and the funds provided for its construction, as well as of the works below Florence, were the proceeds of the sale of 400,000 acres of United States lands within the State of Alabama, to which State the execution and management of the work was confided, with the injunction that it should be commenced at the lowest point of obstruction within the State and be continued upwards until completed. But the money arising from these sales falling far short of the estimated cost of the work, and being evidently insufficient for the accomplishment, the commissioners of the State were subsequently authorized to contract for and construct the part of the canal beginning at Campbell's ferry and running up the river to Lamb's ferry, before that part between Campbell's ferry and Florence, and to connect it with the river at both the eddies; and the plans of the board of internal improvement were so modified as to enable the commissioners to do so.

This canal was built and used for a short time; but as in low water boats could not ascend nor descend the shoals above and below it, and at high water it was not needed, it soon fell into disuse. It is said that the State of Alabama, a number of years ago, had the lock gates burned, and took possession of the iron that was upon them to prevent its being stolen. The masonry of the canal is still in good order, and the tow-path is generally in a good state of preservation; but there are some three feet of earth accumulated in the bottom of the canal, and its dimensions and excavation of 42

feet width at the bottom and 60 feet at the surface, calculated for six feet of water, with locks only 120 feet between the hollow quoins and 32 feet between the walls, are entirely too small for steamboats of any size.

With the construction of the other improvements mentioned a portion of the work expended upon this canal may be made available, but at present it is simply a monument of misdirected energies and of a foolish expenditure of money.

CONCLUSION.

Having been, during the entire time of making this survey, more or less occupied by my duties as principal assistant engineer of the New Orleans, Mobile, and Chattanooga railroad, and having been permitted only by the reluctant consent of Mr. Van Vleck, the chief engineer, to assume the superintendence of this survey, I have been only able to give my personal attention to the examination of obstructions at the Tumbling shoals and Suck, near Chattanooga, and to the most important of all the obstructions, the Muscle and the adjoining shoals.

In my absence the business of my office at Chattanooga was conducted by Mr. Thomas B. Kirby, to whom I am under obligations for his faithful attention to matters placed by me under his care, and also for material assistance in the preparation of this report.

The topographical notes contained in this report are based upon the observations made by Mr. Fred. T. Hampton, and were compiled by him, and I consider them entirely reliable. The maps appended were also constructed by him, under my direction.

The estimates of the cost of removing the obstructions were made by Mr. W. P. Homan, assisted by James C. Long.

I cannot value too highly the services of these gentlemen, who have displayed an ability, industry, and zeal which is worthy of recognition.

Much of the efficiency of the survey has been due to the pilot, Captain T. J. Woodward, whose familiarity with every point in the river, the result of some 21 years' experience, and his strict attention to duty, have enabled him to render very valuable service. It is reported to me that he carried the survey boat over the Muscle shoals at a lower stage of water than a boat of the same draught had ever been able to pass in.

All of which is respectfully submitted.

WILLIAM B. GAW,
Civil Engineer, Chief Assistant Engineer.

Brevet Maj. Gen. G. WEITZEL,
Major of Engineers U. S. A.

APPENDIX K.

IMPROVEMENT OF WESTERN RIVERS, EXCEPTING THE OHIO RIVER.

Annual Report of Colonel J. N. Macomb.

OFFICE OF WESTERN RIVER IMPROVEMENTS,
Cincinnati, Ohio, September 7, 1868.

GENERAL: In obedience to the requirements of the circular from Headquarters of the Corps of Engineers, dated June 10, 1868, I beg leave to present the following annual report upon the works under my charge, as

superintending engineer of the "improvement of the western rivers, except the Ohio river," for the year ending June 30, 1868:

As I stated in my last annual report, the extent of the work required for improving these rivers is so great as clearly to come under the class of indefinite, or "admitting of no permanent completion;" still, the amount of good effected is such as to encourage the continuance of the operations already commenced, and to make an increase in the means and appliances for doing the work; and I have no doubt that with the establishment of boats and machinery, as proposed in my estimates for the fiscal year ending June 30, 1870, which I have forwarded to you to-day, the whole subject will assume a more definite and tangible form, and, indeed, change its character to that of works requiring a moderate annual expenditure for keeping them in a condition satisfactory to the public.

The operations have been conducted under the following heads:

I. Construction of snag-boats and machinery.

II. Examination and survey of western and northwestern rivers.

III. Improvement of Mississippi, Missouri, and Arkansas rivers.

I. CONSTRUCTION OF SNAG-BOATS AND MACHINERY.

At the time of making my last annual report, the snag-boats then under contract were yet upon the stocks, as the water in the Ohio river was too low to admit of their being launched. They were thus delayed until the 18th December, 1867, when the J. J. Abert and the S. H. Long were launched at Cincinnati, and two days later the R. E. DeRussy was launched at New Albany. The severe and inclement weather that followed the launching of the boats prevented their being fitted out as expeditiously as they would have been under favorable circumstances.

It is very gratifying to be able to report to you the perfect success of these boats, after the study and expense that have been bestowed upon them, and after the vexatious delays that occurred in their construction, arising from the necessity of making so many contracts, under the system of awarding the contracts to the lowest bidders for the various kinds of work.

The distinctive feature of these boats consists in having the machinery for pulling snags independent of that for driving the paddle-wheels. This has proved to be as important and useful as was anticipated when I first reported it to you. The experience which has been gained since the commencement of the present working season shows where some improvements may be made in matters of minor detail, while it fully justifies the adherence to the general plan and principle of the double-hulled snag-boat with independent machinery for pulling snags. There was, very naturally, a great anxiety to test the working of the new machinery, inasmuch as no small amount of condemnatory criticism had been bestowed upon our departure from the plans and arrangements of the snag-boats of a former day, by a few of those persons who had seen them or worked on board of them. The test fully realized our most sanguine expectations, and proved that our changes from the old plans, as indicated in the last report, were indeed very great improvements.

Much time and study have been bestowed upon preparing a model with plans and specifications for a light-draught snag-boat, for use upon the Arkansas river, which, having received your approval, will be put under contract with no more delay than what is incidental to the system required by the existing law to be followed in such cases.

It is expected to profit by a careful observation of the working of the

boats, and to submit for your consideration plans for additional ones embracing all the improvements that such observation will naturally lead to. By this course it is hoped that within the next year we may be provided with such a number of most efficient boats as will enable us to push forward the work that they will have to do with all the rapidity its importance demands.

I take pleasure in stating that the merit attaching to the planning and constructing of these boats belongs to Mr. E. M. Shield, the principal civil assistant engineer in this branch of my duties. I can only claim for myself the credit of adopting the plans after a critical discussion of them with him.

II. EXAMINATION AND SURVEY OF WORKS OF IMPROVEMENT, ETC., ON THE WESTERN AND NORTHWESTERN RIVERS.

Brevet Major Howell, captain of engineers, made an exploration of the upper Missouri in the summer of 1867. I had the pleasure of transmitting to you, on the 14th January, 1868, the report of the result of his examinations, and on the 17th of April last, the maps and sketches to illustrate his report, to which and to my own recommendations thereon I now beg leave to refer.

In May of the present year I directed Major Howell to organize a small party for the survey of the lower portion of the Missouri, and, as a measure of economy and convenience, to place the party on board the United States snag-boat R. E. DeRussy, operating in that river. This was done, and the party is still at work there, its chief being Mr. George B. Nicholson, (formerly sergeant company K, 6th Ohio volunteer infantry,) the very efficient and clever draughtsman who prepared the maps and sketches above alluded to of the upper river.

In April, I sent an assistant to the Arkansas river, with instructions to organize a small party to make examinations and report touching all the dangers to navigation existing there; and also to ascertain how far up that river it would be safe to send one of our new snag-boats. And it was upon that information that I sent the S. H. Long there, as stated under the appropriate head. He was also instructed to inquire, in passing, about the wrecks in the Mississippi and in the vicinity of Memphis. Upon this subject his report was forwarded to you on the 13th May last, with my monthly report for April. I send herewith a report from Mr. C. E. Pierce, the assistant last referred to, touching his further examinations upon the Arkansas river, which will show the necessity of a more minute survey there than has heretofore been made.

III. IMPROVEMENT OF THE MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS.

The first work undertaken under this head was the removing of wrecks and other obstructions by blasting. These operations were conducted by my assistant, Mr. C. E. Pierce, whom I had placed in charge of our wrecking steamer, the J. G. Totten. His consolidated report was transmitted to you on the 4th of April last, with my monthly report for March, 1868. A reference to it will show that much labor was bestowed in efforts to remove wrecks in the vicinity of Memphis, Tennessee, and of St. Louis, and at points upon the upper Mississippi, where a more complete success was attained than had rewarded the efforts at St. Louis and below. The steamer Totten, which had been purchased and fitted up for this branch of the business, we had the misfortune to

lose in December last, near Chester, Illinois, as she was on the way to resume work in the lower Mississippi. She had met with very good success in blowing up wrecks with gunpowder, ignited by means of the electric current; but she had not the requisite strength of hull to enable us to use on board of her sufficiently powerful machinery for raising the heavy pieces detached from a sunken wreck by the explosions; and I am satisfied that the operation of "wrecking" can only be thoroughly accomplished by having a boat built expressly for such hard service. Our merchant steamers are either too large and too deep for this service, or else are built with very small timbers to insure a light draught, necessarily sacrificing strength.

The next operation tried under this head was removing obstructions by contract; as reported last year, contracts were entered into for clearing snags, &c., from the Arkansas and Missouri rivers, with parties furnishing men, boats, and appliances for this service. The report of Captain D. Hiner, who was appointed by me to supervise the work upon the Arkansas, was sent to you on the 13th of January, 1868; and I herewith forward the report of Captain J. F. Richardson, (late of our volunteer navy,) whom I employed to supervise the contract work upon the Missouri river.

Since sending in Captain Hiner's report upon the Arkansas work, I have had a better insight into the business of snagging than I had attained at that time, and this determines me to greatly prefer the plan of a shoal-water snag-boat, which I submitted to you on the 12th of August, 1868, rather than that proposed by Captain Hiner, although I approved of his at the time of submitting his report. Captain Richardson also appended to his report a plan for a snag-boat, but for the reason expressed above I do not deem it necessary to forward it.

By Captain Richardson's report it will be seen that, after some three or four months of experience on board of the Underwriter (our charter on the Missouri,) he came to the conclusion "that no boat, unless specially constructed for snagging, can accomplish much good" in that line of business.

My own experience in the two contracts above named, and my observation of the practical working of our three new snag-boats, confirm me in the opinion that it is only by using the government boats, expressly built, manned, and fitted out for this work, that we can expect to make such progress as the nature of the case demands.

I find that those employed upon our snag-boats take a great degree of interest in their work, and every man manifests a strong desire that the boat on which he is employed shall excel each of the others. Thus far the struggle has not been equal among them; for while the party on the Missouri river has been favored with uninterrupted good health, the others, on the Arkansas and Mississippi, have suffered greatly from sickness, the Long losing one man by death, and the Abert losing her captain. In the death of Captain Dodson our work has sustained a great loss. He was our pioneer captain, and he showed a zeal for this particular work which cannot be surpassed. He died at his post, having been actually at work on the deck of the Abert within three days of the time of his death.

In conclusion, I beg leave to submit a brief sketch of the operations of the three new snag-boats, (built in 1867 and 1868,) and also a tabular statement of the amount of work accomplished by each boat, to include the fiscal year ending on the 30th June, 1868; of course much work has been done since that time, but that will be noticed in a future report.

The J. J. Abert was the first to take the field, as all of the contract-

ors for her different parts worked in Cincinnati, and she was consequently equipped completely before leaving here. She sailed on the 23d of March, 1868, to commence operations in that part of the Mississippi river between St. Louis and Cairo. She continued at work throughout the month of April, and reached St. Louis by the middle of May, having destroyed all the snags that were visible on the route at the high stage of water then existing. She then returned to Cairo for certain repairs, and began work on the 10th of June, below that point, and continued down the Mississippi, and reached island No. 14 by the 30th of June, having removed and destroyed 158 snags in all, viz: above Cairo 103, and below that point 55. As these figures convey but an inadequate idea of the labor performed, I would refer to the tabular statement, wherein the dimensions of each snag are given, from which the weights have been computed. The total weight of snags removed by the Abert is 2,708 tons, exclusive of the roots, which it was not found possible to include in anything like exact measure; but as they constitute the natural anchors of the snags, it is easy to see that they added greatly to the labor of lifting, particularly (as it often happened) when they had to be drawn out from their deep beds of mud and sand in the river bottom.

On the 22d April, 1868, the S. H. Long left Madison, Indiana, (whither she had been towed from Cincinnati, to receive her cabins and machinery,) and steamed down the Ohio for the Arkansas river to commence operations. I had received information from an assistant, whom I had sent to the Arkansas some weeks before, that a boat of the dimensions of one of the new snag-boats might go with safety as far up the Arkansas river as Douglass's landing, about 90 miles from the mouth, and work down the river from that vicinity in the course of May and June. I accordingly fixed upon that field as a useful one in which to commence work with the snag-boat S. H. Long. On 30th April she entered the mouth of White river, and passed through the White River cut-off into the Arkansas.

On the way down the Ohio this boat made the first trial of her powers upon a snag at the head of Wabash island. The snag was successfully raised and destroyed. It had been a danger of long standing in the channel of the Ohio river.

On arriving in the Arkansas, the water was found to be too high to work near the cut-off, and the boat proceeded up the stream and commenced work at Floyd Smith's landing, on the 4th of May, and reached Douglass's landing by 9th of May, and worked thence down the stream as far as the post of Arkansas, and from this point worked up the river to Douglass's landing again, as the stage of water became more favorable for the operations in that part of the river. She continued to work in the Arkansas river and White River cut-off until the 20th of June, and in the seven weeks' time spent in that district had removed and destroyed 134 snags, 26 of which were in the White River cut-off.

On inspecting the boat on the 20th June, I found that the water was getting so low as to endanger her, and I therefore ordered the captain to leave Arkansas river and commence in the Mississippi, abreast of Ozark island, and work up the stream towards Memphis. The operations were continued until the boat reached Helena, Arkansas, at the end of June, having destroyed 14 large snags between that place and Ozark island, making in all 149 snags destroyed by the S. H. Long by 30th June, 1868. The work on board of this boat was much interrupted by sickness in the course of the month of June, and we lost one of the crew by death.

A reference to the tabular statement will show that the weight of snags lifted and destroyed by the Long was 2,291 tons, and the same remark as to the weight of roots, &c., will apply as in the case of the Abert.

The snag-boat R. E. De Russy left the landing of Portland, Kentucky, where she had received her machinery and the finishing touches of the joiner and painter, and proceeded around to the Missouri river, which she entered on the 8th of May, 1868, having procured some timber on the route with which to complete her preparations for pulling snags.

Operations were begun on the 11th of May, 1868. Owing to the high stage of water at the mouth of the Missouri, but eight snags were taken out below St. Charles, and a reach of some 20 miles up from the mouth of the river was left to be cleared of snags during the low water usual at the latter part of summer. The operations were regularly and successfully prosecuted as the boat proceeded up the river from St. Charles, and by the 30th of June she had destroyed 222 snags in the Missouri below the vicinity of Hermann, having left the river comparatively free from dangers for the better part of 100 miles, and having gained an experience in the business that will probably enable them to clear out some 300 miles more in the course of the present working season, if favored with a suitable stage of water.

A reference to the tabular statement will show that the De Russy hauled out and destroyed some 2,486 tons of snags, in which, as in the case of each of the other boats, the weight of roots is not considered. It may be remarked, too, in further explanation of these tables, that they embrace many snags the weight of which was not computed, as the dimensions were not given; also that many snags were put out of the way of navigation without having been hauled on board, and are consequently not entered in the tables at all.

In the report of Mr. Shields, which I herewith transmit, there is an estimate for lighting certain reaches of the Mississippi where crossings are necessary, and if the scheme should be approved, as I hope it may, the expense being but some $1,560, could readily be met from the general appropriation for improving, unless it should be deemed to be foreign to character of the works in my case.

I have to express my thanks to Brevet Major Suter, captain corps of engineers, who joined me in July, 1868, for the assistance he has rendered to me, particularly in systematizing and condensing the records of the snag-boats, and in arranging the tabular statements of work done, also for his ingenuity in inventing a table by which the computation of the weight of snags is greatly facilitated.

All of which is most respectfully submitted by your most obedient servant,

J. N. MACOMB,
Col. Eng'rs, Bvt. Col. U. S. A., Gen. Supt. U. S. Snag-boats, and in charge Western River Improvements.

Brevet Maj. Gen. A. A. HUMPHREYS,
Chief Engineer U. S. A., Headquarters Corps of Engineers, Washington, D. C.

K 1.

CINCINNATI, OHIO, *August*, 1867.

COLONEL: In accordance with your appointment and orders of 29th of *August*, 1867, I proceeded to St. Louis and boarded contract steamer

Underwriter, for the purpose of inspecting and supervising the work of said steamer while in the employment of the United States for the purpose of snagging and removing obstructions from the channel of the upper Missouri river, as by contract dated 14th of August, 1867.

September.—The Underwriter, fully manned, equipped and provisioned, with complete apparatus for drawing out snags and wrecking, pumps, &c., for raising sunken boats, and drawing three feet, entered Missouri river September 2d, 1867; found four and a half feet in the channel. We proceeded steadily up the river without interruption, taking a memorandum of all snags and other obstacles in the channel whose removal would benefit navigation.

September 13th, reached a point six miles above Nebraska City, where we found steamer H. S. Turner, sunk by a snag a few days previous to our arrival. By evening of the 20th instant the Turner was successfully raised, and reached St. Louis for repairs. Said boat was in her second year, built in Cincinnati at a cost of $75,000. We also succeeded in saving a quantity of government freight that had been shipped on the Turner. This boat lay directly across the channel, and if allowed to have remained would have proved a serious obstruction.

September 21st, proceeded up the river, but owing to the low stage of water then existing could not reach as high up as Omaha. I then concluded, on account of the rapidly falling river, to work back towards the mouth. Result as follows:

October.—Cleared first right-hand bend above Wyoming, made a good channel through Kansas bend, cleared the bend opposite Brownsville and the first left-hand below St. Cloud; these bends were in a very unsafe condition for passing steamers, and our work there was most opportune and advantageous. Some very heavy snags were removed, measuring three and a half feet in diameter.

At Iowa Point several dangerous snags were removed. Proceeding down to Wilson's, found steamer Lacey snagged and sunk, hull a total loss. We succeeded in saving 300 sacks of wheat, and after removing all the furniture, &c., and the machinery, to the shore, burnt the rest of the boat and tore out the wheels, so that no obstruction should remain. Continued to take out snags from time to time as we found them in the channel; reached St. Joseph October 16th. But few dangerous snags to Leavenworth, which were removed. At Wyandott found drift piles of logs, which were removed and burned; several snags were also taken out at same place. Continued down the river, removing snags from the channel as we found them.

At Goodwin's landing two enormous snags were taken out, also several snags removed at Poverty Point.

November.—Cleared first bend above Brunswick, cleared first bend below Frankfort; found several dangerous snags at Arrow Rock, which were taken out. This place was almost impassable for boats.

On the way down to Jefferson City several snags were removed from the channel, and so on until we arrived near the mouth of Osage river, and found steamer Amelia Poe snagged and sunk, on her way from the mountains to St. Louis. The Poe was in her second year, and valued at $22,000. She was soon successfully raised, and continued on her trip to St. Louis.

We then proceeded on down, removing snags at Hermann, Washington, South Point, Augusta, Doziers, St. Charles, and Camp's landing, arriving at the mouth and finishing our work in Missouri river by evening of December 2, 1867.

My log-book, giving detail of each day's work performed, has been

placed, for reference, in your office in Cincinnati. It will be seen that numbers of drift piles of logs, lodged near the channel, and likely to become dangerous, were burned; also trees were cut where the channel ran close into the bank.

I was well pleased with the working of the Underwriter, and feel satisfied that she was the best boat that could have been obtained for the purpose. I am confident, however, that no boat, unless specially constructed for snagging, can accomplish much lasting good.

Actual number of days' work performed for the United States 71, at the contract price of $275 a day, costing $19,525.

In addition to which, there were 12 days devoted to rescuing sunken or disabled steamers, alluded to in my report, but not counted as part of the work done for the government. The value of property saved in these efforts to aid those steamers in distress amounts to $122,000.

Number of snags removed from the channel of the Missouri river, 164.

Respectfully submitted.

J. F. RICHARDSON.

Colonel J. N. MACOMB,
Corps of Engineers U. S. A., in charge of Western River Improvements.

This extract is a true copy.

J. N. MACOMB,
Colonel Engineers, Brt. Lt. Col. U. S. A.

K 2.

OFFICE WESTERN RIVER IMPROVEMENTS,
Cincinnati, Ohio, January 13, 1868.

GENERAL: I beg leave to submit herewith the report of Captain David Hiner, my supervisor of the contract work of improving the Arkansas river; and in doing this I would remark that Captain Hiner is one of the oldest and most experienced of the pilots on these western rivers, and one among those who rendered valuable and distinguished services in the Mississippi squadron during the rebellion.

On entering the Arkansas from the Mississippi, Captain Hiner fortunately availed himself of the opportunity and of the discretionary power I had given him, and did most important and acceptable service in improving the White river cut-off, the water being so low in the upper river at the time that but little useful work could have been effected there even if he had at once pushed on up the river, and, as it eventually turned out, the contract-steamer Northwest was lost in the upper waters, so that this "cut-off," which is the low-water entrance to the Arkansas, would not yet have been improved if it had not fortunately been done as above named.

The low stage of water continuing, greatly curtailed the extent of useful operations contemplated in the upper river; and only 20 miles of channel above Little Rock was cleared of obstructions prior to the 15th October last. Some time later in the season, a slight rise occurring, the boat reached a point some 30 miles above Little Rock, and continued to work usefully on the upper waters until the 13th December, when she was unfortunately sunk by striking a snag in a deep bend of the river where she was about to land for work.

The work which has been done there seems to have given great satisfaction to those interested in that navigation, and leads to the hope that *with a more* suitable outfit much more may be effected. It will be seen, *by Captain* Hiner's report, that nothing but boats drawing the very

minimum can be made generally useful in the improving of the upper Arkansas, the importance of which improvement he makes manifest.

I respectfully recommend that the plan which he submits, of working two scows, and a small steamer with requisite auxiliary engines and machinery, be adopted. The cost of building these and working them for one year he estimates at $43,420; but for the result which he contemplated, of making a clear channel of thirty inches in depth throughout the navigable portion of the river, in the course of *two* years' time, I should consider that three times the above amount would be an economical expenditure.

I would therefore recommend that the amount of $50,000 should be considered as applicable to this end, for building, equipping, manning, and working the boats, according to Captain Hiner's plan, for the first year. This amount will be readily afforded, if not from the existing appropriations, certainly from those asked for as by my estimates submitted by me on the 19th September, 1867.

The expense of continuing the work proposed to be begun as above will be made the subject of future estimates, if not deemed to be embraced in my estimates for the fiscal year ending 30th June, 1869, above alluded to.

All of which is respectfully submitted by your most obedient servant,

J. N. MACOMB,
Colonel Engineers, Bvt. Col. U. S. A.

Brevet Major General A. A. HUMPHREYS,
Brig. Gen. Comd'g Corps Engineers U. S. A.,
Headquarters, Washington D. C.

CINCINNATI, OHIO, *January* 3, 1868.

SIR: In completion of my duties as government inspector on the steamer Northwest, engaged in improvement of the Arkansas river, I have the honor to report as follows, viz:

In obedience to your orders, received on the 29th of August, 1867, I proceeded with as little delay as possible to Memphis, and from that city to White River cut-off, where I boarded the steamer Northwest on the 7th of September.

On examination, I found the boat and machinery as specified in the contract and the crew efficient.

I commenced operations on the 9th in White River cut-off, and after seven days' work thoroughly cleared that troublesome part of the river of dangerous snags and sunken logs.

Although my instructions did not contemplate work below Little Rock, I felt myself justified in clearing this "cut-off" in view of the discretionary powers granted me and the importance of the work.

This cut-off, five miles in length, is the low-water entrance to the Arkansas river, and its past obstructed condition has caused many disasters. It is now perfectly safe.

On the 16th we left the "cut-off" for the upper Arkansas, and arrived at Little Rock at 6 p. m. on the 22d September. On our way up we found the river very low and falling: at Triplett's bar we found but 26 inches; at Johnson's, but 25 inches; and at Fouche's bar the same. At each of the above-named places we were obliged to pull over with hawsers, and were greatly delayed, as much from sickness on board as from the actual difficulty of pulling over the bars.

At one time on the trip a number of the crew—the captain, pilot, engi-

neer, carpenter, and blacksmith—were so unwell as to be of but little service.

On my arrival at Little Rock, I found the river lower than at any time since the fall of 1863. Boats from above reported but 17 inches on Smith's bar, 20 miles up, and but 13 inches at the mouth of the Delaware, 120 miles above.

The Northwest, drawing 24 inches light, could not pass Smith's bar, and in consequence I was obliged to confine operations to the river immediately above Little Rock, trusting to a rise to carry me further up.

The water I found very clear, and favorable to our work.

As reported on the 15th of October, I had up to that time cleared the channel of obstructions for a distance of 20 miles above Little Rock, and, being unable to proceed further, returned to the latter place, and laid up the boat to await a rise sufficient to carry me above Smith's bar.

There being no immediate prospect of a rise, I availed myself of your permission to take a short leave of absence.

On my return, as reported November 28, I found the river rising slowly, and with sufficient water in the channel to carry me to Beaver Dam, 30 miles above Little Rock. I accordingly repaired to that point, and without interruption continued to work until December 13, when the Northwest, while making a landing for wood in Stanley's bend, struck a snag and sunk, thus putting an end to operations.

Up to the time of sinking our steamer I had thoroughly cleared the following named portions of the river, viz: White Oak bayou, Great House bend, mouth of Little Mammell, Richter's bend, mouth of Big Mammell, bar below Beaver Dam, Beaver Dam, Cling Heifer bend, bend above Cling Heifer, bar below Stanley's bend, and Stanley's bend, making in all about 40 miles.

To the 13th of December we had made 66 working days, including running time, and 17 days for which half-pay is due under the terms of the contract. The work done has given the greatest satisfaction to those interested in the navigation of the river, and has not only removed obstructions, but has also deepened the channel at many shallow places.

In addition to pulling snags I burnt many drift-piles, which would otherwise have furnished fresh obstructions on each rise in the river. With the Northwest I lost my journal, and in consequence cannot give the number of snags removed.

The river bed is sand, easily shifted, and when aided by the presence of snags and logs quickly forms bars across the channel. Where many snags have accumulated at one point in the stream, these bars have sufficient stability to resist the cutting action of the current, and to spread the water over the whole bed of the river, completely blocking the way for boats drawing more than one foot. By selecting that portion of the bed at these points where the channel would naturally be thrown, and there removing the snags, a channel giving 30 inches the year round may be made good to a distance of 200 miles above Fort Smith.

But few new snags are deposited each year in the river bed. The channel once well cleared will require but little after attention. The country along the river is thickly settled, and the finest cotton-growing section of the southwest. Coal is abundant in the upper country, and pine of the best quality.

Although impoverished by the rebellion, the people of this valley are gradually re-establishing themselves, and it will not be many years *before the* trade of the Arkansas basin will become of great and growing *importance*. As the river is the only outlet for this trade, and will so

remain for years to come, its thorough improvement is extremely desirable, not only as a matter of moment to the local interests involved, but as a matter of national importance.

Several government posts receive their supplies by way of the Arkansas, among them those at Little Rock, Fort Smith, Fort Gibson, and Fort Arbuckle. During the low-water season this past fall these supplies were sent semi-weekly by wagon-trains from Little Rock, at an expense of from $3 to $5 per hundred—double the rates of river transportation when available.

Not knowing the tonnage of government freight dependent on this route, it will be impossible to give in figures the economy resulting from proposed improvement; but I believe that in a few years the government will be repaid, by the reduction of its freights alone, for all the expenditure necessary to make the Arkansas navigable as far up as possible.

Since the Arkansas very seldom freezes over, we may safely calculate on being able to work during the whole year, provided boats adapted to very low water be used.

The steamer Northwest, as experience has proved, although only drawing 24 inches, was of too great draught, as are all the boats on the western waters. Economic improvement in the future demands boats specially built for the service.

In this connection my experience leads me to propose the following for your consideration, viz:

That two scows be built of the following dimensions: length 85 feet, beam 18 feet, hold 30 inches, draught six inches; to be strongly decked over and lashed together with oak connecting-beams, so as to leave a space of 10 feet between hulls; to be provided with movable shears, so arranged as to work either between or outside of the scows. Each scow to have either at bow or stern a good capstan, worked by a nigger-engine. To be also provided with crabs and all the necessary implements for raising snags and cutting them to pieces. These two scows thus lashed together to be maneuvered by a small steamboat with but sufficient power to stem the current with its tow, and drawing but 10 or 12 inches. (Similar boats are now running successfully on the upper Arkansas.) The whole outfit included probably not costing more than $25,000. Accompanying this report I send plan of boats suggested. [For diagram see original.]

I would also recommend the following crew, by experience approved as sufficient, viz: One captain, one mate, one pilot, one engineer and striker, one cook, one chambermaid, and eight roustabouts.

I estimate the expense of the proposed boat and crew as follows, viz:

One captain for one month	$200 00
One pilot for one month	150 00
One mate for one month	100 00
One engineer and striker for one month	125 00
One cook for one month	30 00
One chambermaid for one month	30 00
Eight roustabouts, $1 per day each	240 00
Wood, three cords per day, $4 per cord	360 00
Provisions, $10 a day	300 00
Total one month	1,535 00
Total one year	18,420 00

With one boat of this kind I can clear the Arkansas in two years and make a channel-depth of 30 inches throughout its navigable length.

The amount paid the steamer Northwest for 83 days is $11,920, which, compared with the estimate made above, will show the advantage government will derive from building and working its own boats.

I propose working the boats above recommended in the same manner as the double-hulled snag-boats now building, viz: by running over the snags and lifting the latter on board, where they may be cut up and set adrift or carried on shore.

In conclusion, I have the honor to be, very respectfully, your obedient servant,

DAVID HINER.

Col. JOHN N. MACOMB,
Corps of Engineers U. S. A., in charge of
Western River Improvements.

K 3.

CINCINNATI, OHIO, *March* 9, 1868.

COLONEL: I have the honor to submit the following report of my labors and operations with the United States wrecking steamer General J. G. Totten, wrecking and snagging in the Mississippi river, comprising a period from June 7 to December 16, 1867. At short intervals during the above time sub-reports in full detail were submitted, and you were kept advised of my progress and plan of work.

On Friday, June 7, 1867, I left Cincinnati with orders to proceed to remove the wrecks of the White Cloud and Belle of Memphis, sunk in the Mississippi river, near St. Louis, Missouri.

On the 12th of June I commenced operations upon these wrecks. These wrecks laid in the channel, one mile below St. Louis, and a short distance from the right bank.

The river was at a very high stage, and rendered it difficult to work at any advantage; nevertheless I exploded four torpedoes containing 250 pounds of powder, which scattered parts of the wrecks in all directions and showed that blowing out wrecks with powder was a perfect success.

While I was at work upon these wrecks I rendered valuable assistance to the steamer Governor Sharkey, which sunk within a few hundred yards of our boat, caused by being overloaded.

Finding that it was useless to work upon these wrecks at so high stage of water, I left St. Louis on 25th of June, for Memphis, Tennessee, to work upon the wreck Jeff. Thompson. This wreck was a rebel iron-clad gunboat, and laid six miles below Memphis, 80 yards from the right bank, and making a dangerous obstruction to navigation. I was at work upon this wreck two weeks, exploding torpedoes in and about it, and removing large quantities of timber, &c.

On 10th July my divers and pilots examined this wreck, and reported that there was nothing remaining to obstruct navigation in low water, and I commenced search for the wrecks Platte Valley and Beauregard, sunk near here, but was unsuccessful in finding them. The mayor and aldermen of the city of Memphis called upon me to remove the wreck of the St. Louis, lying at the levee.

On the 12th July I commenced work upon the wreck, and on the 19th July I had effectually removed it.

The same day I left Memphis for Cairo, Illinois, and arrived there the 22d with much sickness on board, and proceeded to the wreck of the J. R. Gilmore, which laid one mile below Mound City, Illinois.

On the 26th of July I had removed this wreck, and on the 27th I proceeded to St. Louis, Missouri, for the purpose of procuring powder and tools, which having been received, I returned to Cairo to remove some logs lying in the channel of the river and dangerous to navigation. I had hardly anchored the boat at this obstruction when the cholera broke out on board, and my 2d engineer, Mr. Abram Lappin, died with the disease. I was then taken sick, the crew was discharged, and the boat was laid up until the 13th of August, when I received orders from you to proceed to the wreck of the Northern Light, and arrived there the 26th, and commenced operations upon this wreck. I was very successful with the work here, and on the 10th September I had fully removed this wreck from the channel.

On September 11 I proceeded to Keokuk, Iowa, and arrived there the 17th. I had difficulty in passing over the lower rapids, and was obliged to hire a barge to take our tools, &c.

On the 20th of September I commenced to remove obstructions in the river between Keokuk and Quincy, Illinois. Near Keokuk I removed two large snags, and at Alexandria, Missouri, two large snags. Four miles below Alexandria I examined the wreck of the Dominion, and found it not dangerous to navigation. At Gregor's landing one large snag and several small ones. At Dodd's landing I took out three large snags, and at Price's landing one large snag. At Quincy, Illinois, I received an order from you to proceed to St. Louis, Missouri, to work upon the wrecks White Cloud and Belle of Memphis.

Between Keokuk and Quincy I had removed every obstruction that was dangerous to navigation, except one large rock, and I should have removed that had I not received your order to proceed to St. Louis.

On the 26th of September I arrived at the wrecks Belle of Memphis and White Cloud, and commenced work. Upon examination again of these wrecks I found that there were four wrecks.

During the remainder of this month (September) and until October 30 I was employed at these wrecks, removing all the debris I could. There was not sufficient power in the boat to remove everything.

October 30 I left St. Louis for Hat island, near Wittenberg, Missouri. At this island I removed five large snags; rendered assistance to the steamers Victory and Julia, aground.

At Wittenberg, Missouri, I removed four large snags. I proceeded from here to Alton, Illinois, to remove the wreck of the Resolute. I arrived there the 13th of November and commenced upon this wreck. On the 19th of November I had removed this wreck from the channel and proceeded to the wreck of a coal barge near Grafton, Illinois. I commenced work upon this wreck the 22d, and removed it.

On the 25th I arrived at the wreck of the Baltimore, nine miles above St. Louis. I removed the shafts and snags about this wreck, but did not think it advisable to work here, as the wreck was in a very shoal place.

On 26th November I proceeded to the wreck York State, at Madison landing, Illinois. Cold weather and snow prevented me from doing much here, and I only removed one shaft. From here I went to St. Louis, discharged the crew, and had the boat docked and repaired.

December 13 I left St. Louis for Memphis, Tennessee. At Saline island, near St. Mary's, Missouri, I was aground 10 hours.

On the 16th of December, seven miles below Chester, Illinois, the boat struck a snag and sunk. I did all I could to save her, but was unsuccessful.

I found at all wrecks that I labored under great disadvantage, on account of the insufficient strength of the boat, and the want of a barge. In blowing a wreck to pieces a great deal of the débris is too heavy to float, and a barge to place this débris upon saves a great deal of labor and time.

Had the boat been of sufficient strength, there were many pieces of machinery that could have been removed from wrecks and sold, and lessened the expenses of the boat one-half. At the wreck of the Northern Light I could have taken out all of the machinery in good order had the boat been strong enough. With two 16-inch Lattie pumps I think I could have raised the whole wreck, and when raised it would have been worth $30,000.

In removing snags and sunken logs I found powder was a great saving of labor and time. Some of the snags that I removed were so firmly imbedded in the mud that it was impossible to remove them without the use of powder.

With what experience I have had in wrecking, I think that pumps can be used to a great advantage in raising wrecks and washing or dredging out a channel through sand-bars, which I explained to the board of engineers at Pittsburg. A boat of the kind I presented before the board of engineers can run in any river that is navigable, and will not draw over 24 inches of water. It can be made for dredging, snagging, and wrecking, and the cost will not exceed $65,000.

If the engineer department should not deem it advisable to build a boat of this kind, I would recommend that the cranes, diving apparatus, &c., saved from the steamer Totten, be placed upon the boat at New Albany, which can be done without much incumbrance to the boat, and the expense would not exceed $5,000. The boat then could be used at wrecking as well as snagging, and could remove any obstruction that it came in contact with.

I remain, very respectfully, your obedient servant,

C. E. PEIRCE,
U. S. Assistant Engineer and Master in charge of the U. S. Steamer General J. G. Totten.

Colonel J. N. MACOMB,
Corps of Engineers, Cincinnati, Ohio.

K 4.

CINCINNATI, *March* 27, 1868.

SIR: I have the pleasure to report that the double-hulled snag-boat Colonel J. J. Abert has been inspected and accepted as completed, and I recommend that the contractor be released The long and unusual delay in the construction of this vessel demands a palliative that will relieve the detention. The extreme low water of 1867 in the Ohio river prevented the launching of this boat until the 18th of December of that year, fully three months later than the contractor agreed to have her in

the water. This unavoidable delay and the continuous inclement weather of January and February further impeded the erection of machinery, joiner-work, and painting, and caused all these various contracts to be unavoidable as to specified completion. The hulls are fully up to the contract in excellence of material and workmanship, and the deviations made from the specifications have all been favorable to the government and beneficial to the boat. The machinery has been executed in compliance with the specifications as to dimensions given, and the contractor has at all times shown a willingness to have the work done in his usual style of excellence. The cabin and joiner work is one of the best executed pieces of work in the line of steamboat wood-work that have come under my notice. Painting is well done, and the materials used come fully up to the specifications. Furnishing is fully up to the standard of first-class steamboats. Beds and bedding are excellent, and the tinware, pumps, and stove arrangements are of a superior order of work. "Miscellaneous," consisting of hand and steam fire-pumps, axes, saws, buckets, hose, and tools of various kinds, are fully up to specifications. The distribution of machinery on this boat is complete, and the trim of hulls, attested by the draught of water, substantially shows there cannot be any improvement of this desired aim.

Steam was raised on March 7, and the machinery partially tested to trace defects that ordinarily exist in all our new steam machinery. The trial was satisfactory, and immediate preparations were made to get the boat off at the earliest opportunity. The finishing of cabins, outfit for same, and the various required appliances, were not fully completed until the 20th of March. On Monday, the 23d, the officers and crew were assembled, steam was raised, and the Abert started for her field of practical work at 2.30 p. m. The boilers generated steam freely and supplied the cylinders continually with a pressure of 100 pounds to the square inch, and will increase this pressure, after a few days, with an economic use of fuel. The machinery performed admirably, and the speed of the boat is fully up to all expectations. The work, as a whole, in its execution is creditable to the mechanics engaged. Regarding the adaptability of this boat for the purpose of removing snags with rapidity and economy, I feel justified in stating that I cannot, at present, offer any suggestions for improvements. The practical working of the boat may show defects of detail, but cannot affect the general appliance.

The S. H. Long, finishing at Madison, Indiana, is progressing at a snail's pace, and I fear difficulties are increasing that may prevent her getting below the falls on this rise of water. The R. E. De Russy will be completed by the 15th of April. The contractors show a disposition to fully comply with their contracts, which is refreshing when compared with the parties at Madison.

E. M. SHIELD,
Assistant in charge of Construction of Boats and Machinery for United States Western River Improvements.

Colonel JOHN N. MACOMB,
Corps of Engineers U. S. A., in charge of Western River Improvements.

A true copy:

J. N. MACOMB,
Colonel of Engineers, Brevet Colonel U. S. A.

K 5.

Monthly report of Colonel J. N. Macomb, corps of engineers, brevet colonel United States army, superintendent of government snag-boats, in charge of western river improvements, &c., for April, 1868.

OFFICE OF WESTERN RIVER IMPROVEMENTS,
Cincinnati, Ohio, April 13, 1868.

GENERAL: I beg leave to submit herewith copies of reports to me from my assistants, as follows:

1. Monthly report of Major C. W. Howell, corps of engineers, for April, 1868.

2. Final report on the construction of the three double-hulled snag-boats, by Mr. E. M. Shield.

3. Report of Mr. C. E. Peirce, touching the condition of certain wrecks in the Mississippi river, at and in the vicinity of Memphis, Tennessee.

In the early part of the month I was engaged in the usual office duties here, particularly with the quarterly papers for the first quarter, 1868. From the 13th to the 17th of April I made the inspection of the contract work of the government snag-boats Colonel S. H. Long, at Madison, Indiana, and General R. E. De Russy, at Portland, Kentucky. On Wednesday, the 22d, the Long left Madison, Indiana, and proceeded down the Ohio, with orders for commencing work in the Arkansas river. On Saturday, the 25th, her crew removed a snag from the channel of the Ohio river at the head of Wabash island. Our attention was called to this obstacle on the evening of the boat's departing from Portland, Kentucky, and the captain of the Long was directed to make his *coup d'essai* upon this snag, which proved to be a monster and a serious danger to upward-bound steamers. It was removed and destroyed in a reasonable length of time, and the snag-boat proceeded on her way and entered the Arkansas river via the White river cut-off, and arrived at the Post of Arkansas at five o'clock p. m. on 30th April, 1868.

My instructions to the captain are to do what work in the Arkansas he may find it possible to do, and to withdraw from there whenever the water may become too low for his boat to work there in safety. He will then return to the Mississippi and work towards Memphis until further orders.

On the 1st of April I sent Mr. C. C. Pierce, assistant engineer, to the Arkansas river to inform himself of the nature and extent of the dangers to the navigation there and at the wrecks near Memphis, where he had worked last year, and instructed him to report to me as soon as possible upon these points, and particularly as to the distance up the Arkansas it would be safe to send one of the double-hulled snag-boats. On this latter point I am informed by him, under date of 13th April, that it is deemed safe to work one of these boats in that part of the river below Douglass landing, at which place much work is needed. It is on this information that the orders to the Long are predicated. Douglass landing is some ninety miles from the mouth of the Arkansas.

On the 29th I went to New Albany, Indiana, to see to the arranging of the accounts of the United States snag-boat R. E. De Russy, prior to sending her to the Missouri river, for which point she started on the 30th of April, from the wharf at Portland, Kentucky, where she had been finished. My absence from here on the above named duty, and on that of inspecting the J. J. Abert, (to be reported upon after the end of the present month,) will explain the delay in rendering this monthly report, for which my letter of the 9th instant, from St. Louis, will have prepared you.

I would respectfully refer you to the accompanying report of Mr. E. M. Shield, herewith submitted, especially to his remarks upon the great difficulty involved in the plan of getting mechanical work done under the existing system of advertising and contracting with lowest bidders. As Mr. Shields has had a life-long experience in the operations of practical mechanics, and is an expert in all matters relating thereto, I attach the utmost importance to his opinions on this subject, and I wish to express my hearty concurrence in his views after a careful study of the matter during the last 18 months. And I feel it a duty to record officially my sincere thanks to him for the very thorough manner in which he has caused the work of constructing the snag-boats and machinery to be done. To his intelligence, industry, and watchful care for the interests of the government, we are indebted for a remarkably successful result.

All of which is respectfully submitted by your most obedient, humble servant,

J. N. MACOMB, *Colonel Engineers,*
Brevet Colonel U. S. A., Superintendent Snag-Boats,
and in charge of Western River Improvements, &c.

Brevet Major General A. A. HUMPHREYS,
Chief of Engineers, United States Army,
Headquarters of Engineers, Washington, D. C.

K 6.

OFFICE WESTERN RIVER IMPROVEMENTS,
Cincinnati, Ohio, May 3, 1868.

SIR: I have the honor to report during the month of April the following duties performed by myself, viz: Sketches of the Missouri river finished and forwarded to the engineer department in Washington; surveying party organized to accompany the snag-boat De Russy, and now waiting answer to requisition for instruments; the usual office duty.

The surveying party to accompany the De Russy I have placed under the direction of Mr. G. B. Nicholson, civil engineer.

It is intended to make an accurate topographic and hydrographic survey of those portions of the Missouri river from which obstructions are removed, and to collect all the information at command concerning local changes and characteristics. In addition, a meteorological record will be kept by the party.

Mr. Nicholson and party will start from this point on the receipt of the necessary instruments.

I have the honor to be, very respectfully, your ob't. servt.,

C. W. HOWELL,
Captain of Engineers, Brevet Major U. S. A.

Colonel JOHN N. MACOMB,
Corps of Engineers, United States Army.

CINCINNATI, *Ohio, May* 13, 1868.

SIR: I beg leave to report the two double-hulled snag-boats S. H. Long and R. E. De Russy, built under your supervision, as completed and placed in commission.

The S. H. Long, fully officered and manned, having 90 days' provisions on board, left Madison, Indiana, April 22, bound for the Arkan-

sas river, as per your order issued April 21. I deemed it worthy of trial to reduce the number of men on board of the S. H. Long as follows: one steersman and two deck hands. If the number so reduced on this boat proves to be sufficient for the service, a similar change may be made on the other boats, which will reduce the working expenses on the three boats $500 per month.

The R. E. De Russy left Portland, Kentucky, April 30, as per your order of the 29th, fully officered and provisioned. I accompanied the De Russy from Portland, Kentucky, to St. Louis, Missouri. Her machinery worked well, and her speed much faster than was anticipated. The officers and crew filled the various positions assigned with ability equal to any employed on western steamers. The officers of the three boats recommended for your approval and appointment have been selected with due care for the service to be performed. The stagnation of the western boating interest has thrown a larger number of men out of employment than has been idle since the first year of the war; and it has been a delicate and difficult task to make selections from so large a number of applicants without giving offense to those not employed. Selections of both officers and men have been made at the points the boats were built, viz: Cincinnati, Madison, Indiana, Louisville, Kentucky, Portland, Kentucky, and New Albany, Indiana.

My report of March 27 on the completion of the J. J. Abert, as to the mechanical execution of the work by the contractors, will, with a few trifling exceptions, apply to the S. H. Long and R. E. De Russy. I, however, deem it of sufficient importance to embody in this report the faithful and liberal manner in which Dennis Long, the builder of the machinery erected on the De Russy, has executed the contract awarded to him, and I cheerfully recommend Mr. Long to your special approval and favorable notice in any future contracts for machinery you may have to dispose of.

I desire to call your attention to the system of awarding contracts to the lowest bidder. The experience gained in building these boats proves how fallacious the system is, when practically demonstrated in the execution of mechanical work of the character of which boats and machinery partake. No samples, save the reputation of the builder, can be furnished; and it is impossible, no matter how closely or clearly specifications may be drawn, or how well guarded by inspection, the inferior mechanic will evade the proper execution of the work.

The competition in all the mechanical branches pertaining to boat-building are so extensive in the west, that at all prominent cities bordering on the rivers selections can always be made of the best, and in numbers sufficient to insure fair bids and an equivalent return of the moneys expended.

This being my final report on the construction of these snag-boats, it affords me pleasure to express my warmest thanks to you for the kindness and confidence you have at all times shown me.

E. M. SHIELD,
Assistant in charge of Construction of Boats and Machinery for United States Western River Improvements.

Colonel JOHN N. MACOMB,
Corps of Engineers, United States Army,
In charge of Western River Improvements.

A true copy:

J. N. MACOMB,
Colonel Engineers, Brevet Colonel U. S. Army.

K 7.

MEMPHIS, TENN., *April* 10, 1868.

SIR: I have the honor to report my arrival at this place on the 8th instant, at 12 noon, and immediately commenced getting information in regard to the wrecks spoken of in my letter of instructions.

I called on a number of gentlemen, also, on the wharf-boat Hamstead & Co., and learned from one of the clerks, (Mr. Chamberlin,) whose place of business is within 100 feet of the old wharf-boat which was blown out by the United States steamer Totten, who says there is nothing remaining in the way except a part of her bottom, and some pieces which were blown loose and would not float away, and is not dangerous. I also obtained the same information from a steamboat agent, Mr. T. R. Kirnaw, whose business is on the wharf, in regard to that portion which is left. I always knew it, and told the mayor of the city at the time, that it was impossible to remove it then, as her side had been torn away and was covered with mud; and he said he did not care, for he could remove that when the water was low, and that he would do it; but he has failed to do so.

In regard to the wreck of the Jeff. Thompson, I also made inquiry, the water being so high that it was impossible to make a personal examination. There seems to be a difference of opinion among the pilots here. Some say they think the "hoop-pole boat" struck it, and others do not. Mr. Hiram McNeely, who is master of a tug-boat and a pilot, and whose business calls him in that direction during all seasons of the year to sound for other boats, says that he saw the piece which it did strike, and it was blown from the wreck, but could not float, or was held fast by an iron rod or hog-chain; also that the wreck was blown in all directions, and is dangerous when the water is low. There are 25 feet of water on the wreck now. The boats have to pass within 50 feet of it at nine-foot stage, which makes it bad on account of the changes in the channel, and then it is that it is considered dangerous, but it is not one-half so dangerous as before.

The wreck of the Platte Valley is now very much in the way, a great deal more so than the Jeff. Thompson; and also the wreck of the Beauregard, which is very much in the way and should be removed. As to the best way to remove it I will write you some other time, as the boat on which I leave for Arkansas leaves to-day.

I remain, very respectfully, sir, your most obedient servant,

C. E. PEIRCE,
Assistant Engineer Western River Improvements.

Colonel J. N. MACOMB,
Colonel of Engineers, Brevet Colonel U. S. Army.

A true copy:

J. N. MACOMB,
Colonel of Engineers, Brevet Colonel U. S. Army.

K 8.

FORT SMITH, ARK., *April* 20, 1868.

SIR: I have the honor to report my arrival at this place on the 19th instant. I left Little Rock for this place on the 16th instant, at 11 o'clock a. m. While there I went and made an examination of the wreck

of the steamer Rodolph, which I find a very bad obstruction, there being nine feet of water now on the highest parts. The water at this time is about eight feet higher than usual low water, and the wreck does not show out of water unless it is at a very low stage; therefore it makes a very dangerous obstruction, but there will be no trouble in removing it. It is situated about 20 miles below Little Rock, near Pennington's landing, and lies directly in the channel, there being from 15 to 18 feet of water around the same now.

In coming up the river I passed several places which I made note of. There are also snags scattered all the way along. The first place of note was called Rector's bend, or Hell's half-acre; this is a very dangerous place, it being full of snags and stumps, so that it is almost impossible to pass. Six miles above, Devil's bend; this is also full of snags and very dangerous, and continues full to Natural steps. This is a very bad place, there being a great many snags scattered all along the way to Bentley's reefs or bar; this is considered a very dangerous place. There have been seven boats wrecked at this place; there are both rocks and snags at this place in the way. Owing to the high water I could not see the real condition of it, but shall on my return down stop and examine the same and will report in my next. Bentley's Point, six miles above, is also a very bad place. The next place is very bad; it is near the mouth of the Petite Jean, which is also very full of snags and stumps. Twelve miles above here is Hog Thief bend, which is a very bad place, it being full of snags and stumps. The next place is near Pittsburg landing, 140 miles above Little Rock. There are a great many snags; also the wreck of the Florence Traber, which lies badly in the way and should be removed. This boat was sunk about three weeks ago by striking a snag; also the bend above Patterson's bluff is very dangerous; the steamer Hesper was sunk at this point about the same time, but is not in the way. McLain's bottom is also full of snags, and the wreck of the steamer Des Moines City, which is very much in the way; this place is about 175 miles above Little Rock. The next place is the mouth of Frog bayou, which is also very dangerous and full of snags. The next bad place is at Moore's Rock, 225 miles above Little Rock; this is considered the worst place on the river. At this place I shall also make an examination immediately, and report the condition of the same in my next. It is also very snaggy for the next four miles, at a place called Trustee's bend; and also the wreck of the steamer Trustee is very much in the way; and it is also very snaggy all the rest of the way to Van Buren, making it very dangerous. We struck one with the boat in which I was a passenger, but it caused no serious damage. Three miles above Van Buren is the wreck of the steamer Resolute, which is very much in the way and should be removed; and there are also very many snags all the way from Van Buren to Fort Smith, and is considered to be one of the most dangerous parts of the river. I find that the best way to remove these obstructions, in my opinion, would be to have a flat-boat of sufficient size and strength, with capstan, shears, and nigger-engines, with boilers complete, of which I will send a sketch. One-half of these snags can be taken ashore easier than any other way. With a boat of this kind I can remove wrecks, rocks, or any obstructions that may be in the way. There should also be a small steamboat connected with the same, so it could be towed from one place to another, and also accommodate the working party. While at Little Rock I made inquiry with regard to facilities for building a flat-boat of this kind. I find they are good with the exception of machinery. I also inquired about steamboats; I could not find but one that would *charter* by the day and that is owned by Mr. J. L. Adams, of Little Rock.

The name of this boat is Fort Smith. It is a very light draught, only nine inches, and of sufficient power and room; and the lowest price per diem was $100, without any crew whatever, and would not sell at any price. I called on Mr. G. W. Brant, of Hamilton, Ohio, who was stopping at that place, and who also owns the steamer Hamilton, a stern-wheel boat, who offers it for sale at a reasonable price, a description of which I will give, viz: Length, 110 feet; breadth, 22 feet; depth of hold, three feet; size of cabin, 10 state rooms; draught of water, one foot; size of timbers and frames, four inches by two and one-half inches; thickness of plank, two and one-half inches; number of boilers, two; length, 16 feet; diameter, 30 inches; number of engines, two; diameter of cylinder, nine and one-half inches; stroke of engines, 30 inches; one doctor-engine complete; length of wheel, 11½ feet; diameter of wheel, 13½ feet, and was built in Cincinnati, in July, 1867, and has one nigger-engine, capstan, and necessary outfit of pipes, spars, &c., that is needed on a boat of that size. I have not seen a boat that would answer to work in this river as well as this one, except the Fort Smith, and I think it very cheap at the price they offer it, which is only $7,000. With an additional outlay of $1,000 I could make it the best boat we could have for this river. In regard to the flat-boat, I find that I can build it for $1,000, that is, without the machinery, which will cost $1,000 more, by working in what I can of the Totten's machinery. The expense of running and working the party per month now, viz:

One captain	$250
One pilot	200
One engineer	150
One engineer	100
One clerk and steward	125
One mate	125
One cook	75
Two watchmen, at $75	150
Fourteen deck hands, at $40 per month	560
Three cabin boys, at $25	75
Fuel	500
Subsistence of officers and crew	650
Oil, sundries	200
Total	3,160

Such a boat as this is very much needed, and I would recommend that such a one be purchased and immediately set to work.

I do not think that I shall be able to go to Fort Gibson, as there is no boat running there at present.

As soon as I finish my examinations I shall return to Little Rock and there await your orders. Please direct all mail to Little Rock. I should like to hear from you as soon as convenient, so that I may know what I am expected to do.

I am, very respectfully, your obedient servant,

C. E. PEIRCE,
United States Assistant Engineer.

J. N. MACOMB,
Colonel of Engineers, Brevet Lt. Col. U. S. A.

A true copy:

J. N. MACOMB,
Colonel of Engineers, Brevet Lt. Col. U. S. A.

Abstract of proposals received on account of construction of snag-boats during fiscal year ending June 30, 1868.

Names of bidders.	Residence.	Designation.	Amount.
Samuel Cummings & Son.	Cincinnati..	Miscellaneous outfit for 3 snag-boats..	$6,651 75
Jacob Gominger.....	Cinciunati..	Yawls for 3 snag-boats.....	570 00
John De Camp.....	Cincinnati..	Cabin outfit for 3 snag-boats.....	6,681 33

Abstract of contracts made on account of construction of snag-boats during fiscal year ending June 30, 1868.

Names of contractors.	Residence.	Designation.	Amount.
Samuel Cummings & Son.	Cincinnati..	Miscellaneous outfit for 3 snag-boats..	$6,651 75
Jacob Gominger.....	Cincinnati..	Yawls for 3 snag-boats.....	570 00
John De Camp.....	Cincinnati..	Cabin outfit for 3 snag-boats.....	6,681 33

K 9.

CINCINNATI, OHIO, *August* 24, 1868.

SIR: The continued successful working of the snag-boats built under your supervision is a source of much gratification to me to report, and I have but little to offer in suggestion of any kind or character for their further improvement.

Snags of colossal size have been removed from the beds of the Missouri and Mississippi rivers, in many cases old and troublesome residenters that were known by pilots now in service for over a score of years, and there is yet to be reported a single instance of a snag having been passed for the want of appliance or power to remove it.

In a report to Congress, June, 1844, by a select committee, recommending the payment of a sum of money to Henry M. Shreve for his invention of a steam snag-boat, it is embodied in the report that the first steam snag-boat, Heliopolis, in 1829, raised a tree 166 feet in length, and 3½ feet in diameter; and on another occasion one that was planted 20 feet in bed of river—at that period of time, near 40 years ago, we may truthfully say a wonderful achievement, but at this day, and with the present snag-boats, a work that would be performed inside of 15 minutes. And had the inventor and his attachés kept pace with the improvements and progress of mechanical arts, there is no doubt but snagging would have reached a high state of perfection in 1852, the period at which the business was abandoned. It is, however, a notable fact, and one of record, that the snag-boat of 1852 was the Heliopolis of 1829.

The present snag-boats, with, of course, improved machinery over the Heliopolis of 1829, and their hoisting machinery acting independent of the propelling power of the boat, have pulled and disposed of snags of the following dimensions:

April 8, 1868—Snag-boat J. J. Abert pulled at Devil's island, Mississippi river, one snag, 104 feet long, 6 feet 3 inches diameter at butt, and 3 feet 3 inches at top.

April 11, 1868—One snag 130 feet long, 6 feet 4 inches at butt, and 3 feet at top.

June 13, 1868—One snag 135 feet long, 5 feet 2 inches at butt, and 4 feet at top.

April 25, 1868—Snag-boat S. H. Long pulled at head of Wabash island, Ohio river, one snag 99 feet long, 7 feet at butt, and 3 feet 3 inches at top.

June 12, 1868—Snag-boat R. E. De Russy, one snag 97 feet long, diameter at butt 6 feet 1 inch, and at top 3 feet.

June 16, 1868—One snag 119 feet long, 7 feet diameter at butt, and 4 feet 4 inches at top. This snag was imbedded 27 feet in bed of river, was removed and brought into cradle with its accumulation of soil adhering to its roots, without having broken a single portion of the machinery or rigging; so heavy was this tree that the hulls were depressed 18 inches over their usual draught of water by its weight of about 75 tons.

Two of the boats, the S. H. Long and the J. J. Abert, working in the lower Mississippi and Arkansas rivers, are now lying up in the Ohio river at Mound City, Illinois, both being compelled, from sickness of officers and crews, to go out of service. It affords me pleasure to say that the S. H. Long having her officers and crew reorganized, will again go into service on the 27th, and the Abert on or about the 1st of September.

I would respectfully ask your investigation of the following suggestion for the improvement of the navigation of the Mississippi river from Cairo to Memphis, a part of the river known to be the most dangerous:

There is on this line a large number of persons engaged in cutting and selling wood to passing steamers, whose service could be brought into use at a trifling compensation. I feel justified in saying that their services would be given gratis, from the fact that in so doing they would add largely to their sales by the publicity of their several wood yards.

The Mississippi pilots residing at Cincinnati, Louisville, and St. Louis, be requested to meet and designate say 25 points, between Cairo and Memphis; at each of these points designated have a reflector lamp which shall be lighted and run up over a pulley, to a height of say 40 or 50 feet; the lights thus placed would be beacons, and could be seen a mile distant, either by a descending or ascending boat. These beacons thus arranged would be marks for pilots to make their crossings, and a few trips would so familiarize them that this portion of the river would become comparatively safe as it is now dangerous.

The expense of this arm of the service, independent of attending to the trimmings and hoistings of lights, would be as follows:

25 lamps, with 1 rear reflector of 12 inches diameter and 2 side reflectors of 10 inches diameter, at $10 each lamp....	$250 00
25 wooden hoods to be fastened to top of pole, with pulley and lanyard for hoisting lamp, the inside of hood to be painted black, at $5 each.....	125 00
25 poles and planting, at $2 each.....	50 00
25 dozen wicks for one year's service, at 12 cents per dozen....	3 00
150 glass chimneys, 6 to a lamp, at $1 50 per dozen.....	18 75
25 tin oil-fillers holding one gallon each, at 50 cents per can..	12 50
Consumption of oil for each lamp per night, at 12 cents, for one year, 365 nights, $43 80, and for the 25 lamps.....	1,095 00
Whole cost of lamps and outfit.....	1,554 25

I would further commend to your immediate attention the building of two light-draught snag-boats; one to be placed in hands of builders at the earliest day possible, and when completed to be ordered to the Arkansas river for continuous service; the other, after a test of adaptability of the first for service, to be placed in the upper Missouri. Both of these rivers may be termed specialties, and must have boats and machinery applicable to the peculiar condition of these rivers. Having placed models, specifications, and estimates of cost of building in your possession for approval, I deem it unnecessary to embody in this report the estimates for these boats.

I would also suggest for your consideration the building of one more boat, similar in construction to the boats now in service, this boat to be used on the Missouri river with the following changes in dimensions of hulls: One additional foot of beam to each hull, three feet additional floor, five feet additional length.

A boat with these additions of dimensions can be brought out on a draught of water not exceeding three feet, this being as light a draught of water, having the necessary strength of timbers and suitable appliances, as can well be expected from one boat having to carry all the appliances necessary for the work required.

This proposed boat can be contracted for at the present time under very favorable prices to the government, for the reason that all the western ship-builders are idle, and would be willing to build at reduced rates from the prices paid for the boats now in service. I am justified in saying that $35,000 per month will be all the funds required to make payments on this boat until completed, which would be in May, 1869, being as early a date as could be expected to get in the Missouri for practical work.

I feel that I would be doing violence to my feelings were I not to embrace in this report expressions of sympathy for those who have died in the harness of the service. James Maguire, attached to the engineer service on board the United States snag-boat S. H. Long, died, June 27, of congestion of the heart. His sickness was of brief duration. It is reported that he had all the attention in his illness that was in the power of the officers to give him, having the services of a physician and the attention of his comrades. He was buried on the banks of the Mississippi in a private burial ground.

Wm. B. Dodson, pioneer captain of the pioneer United States snag-boat J. J. Abert, died on board at Cairo, Illinois, after a brief illness, August 11. For several weeks previous to his death his crew had been reduced by sickness and desertion, to an extent that compelled him to make the port of Memphis for additional men. Combating with these difficulties he exposed himself, and labored beyond his strength to bear. He was compelled, after exhausting his principal officers, to run for the harbor of Cairo, Illinois, with a view of reorganizing for future operations. There is no doubt that the seeds of the disease which caused his death had laid hold of his system for weeks previous, and only the excitement of his duties kept him on his feet. A few hours after his arrival with his boat at Cairo he was found insensible, and in a space of 48 hours from that time death relieved him from his watch. I am cognizant of the fact that he aimed to place himself ahead of his colleagues in the amount of work to be done, and in striving to do this lost sight of what was due those under his command. I am not competent to place on paper what I feel is due to his memory; his faults and foibles were errors of the head only, and but grains of resist-

ance against tons of merit. May we not hope that when the Great Commander pipes the chosen ones aloft, Dodson will be of the elect.

E. M. SHIELD,
Principal Assistant in charge of Construction of Boats and Machinery for U. S. Western River Improvements.

Colonel J. N. MACOMB,
Corps of Engineers U. S. A.,
in charge of Western River Improvements.

True copy:

J. N. MACOMB,
Colonel Engineers, Brevet Colonel U. S. A.,
General Superintendent U. S. Snag-boats
and Western River Improvements, &c.

K 10.

List of snags pulled out and cut up by United States snag-boat R. E. De Russy.

Date.	No. of snags.	Length of trunk.	Circumference of butt.		Circumference of top.		Kind of tree.	Estimated weight in tons, 2,000 pounds.	Locality whence taken.
1868.		*Ft.*	*Ft.*	*In.*	*Ft.*	*In.*			
May 11	1	89	12		7		Sycamore	16.	Mulanply island, Missouri river.
11	1	68	17		11	6	....do.....	27.8	Foot of Sturgeon's Bend.
12	1	91	11	6	8		Cottonwood ..	17.3	Do. do.
12	1	76	11		8	6	Sycamore	14.4	Do. do.
12	1	88	14	6	11	6	....do.....	29.9	Do. do.
13	1	84	13		8	6	....do.....	20.5	Head of Mulanply island.
13	1	30	7		5		....do.....	2.1	Below Holmes's island.
14	1	67	15	6	11		...do	23.4	Abreast of Holmes's island.
14	1	57	9		6	6	Cottonwood ...	6.8	One mile above Penn's wood-yard.
15	1	128	15	6	8		....do.....	37.5	Do. do.
15	1	71	10	6	7	6	Sycamore	12.1	Do. do.
15	1	35	8		6		... do.....	3.5	Head of Mitchell's wood-yard.
15	1	38	4	6	3		Cottonwood ...	1.1	Howard's Bend.
16	1	73	12	6	8	6	Sycamore	16	Do.
16	1	48	8		2	6	....do.....	2.9	Do.
16	1	132	13		7		....do.....	27.7	Do.
16	1	71	14	6	9		....do.....	19.9	Head of Howard's Bend.
18	1	93	15		12		Cottonwood ...	33.5	Do. do.
19	1	123	14		8		....do	30.7	Do. do.
19	1	129	14		8		....do.....	32.2	Do. do.
19	1	125	11	6	7	6	....do.....	22.5	Do. do.
20	1	77	14		10		....do.....	22.3	Foot of Bonhomme Island.
20	1	141	15		9		....do.....	40.9	Do. do.
20	1	40	3		1		Elm	.3	Do. do.
21	1	91	9		5		...do.....	9.1	Do. do.
21	1	58	11	6	9		Sycamore	.....	Foot of Post's island.
21	1	48	4		2		Cottonwood ...	.....	Do. do.
21	1	115	17		9		...do.....	.....	Head of Post's island.
22	1	65	6		2	6	Sycamore	.....	Foot of Howell's island.
22	1	42	6	6	3		Cottonwood ...	.....	Do. do.
22	1	73	8		3		....do.....	4.4	Abreast of Howell's island.
22	1	67	4	6	3		....do.....	2	Do. do.
22	1	46	11		5		....do.....	6	Do. do.
22	1	67	4	6	2		...do.....	1.6	Foot of Howell's island.
22	1	76	7		3		....do.....	3.8	Do. do.
22	1	35	14		12		....do.....	11.9	Do. do.
23	1	50	6		4		....do.....	2.5	Do. do.
23	1	71	7	6	3		....do.....	4.3	Head of Howell's island.
23	1	35	12		9	6	....do.....	8	Do. do.
23	1	59	14	6	9	6	....do.....	17.1	Dozier's landing.
23	1	63	17	9	10		Sycamore	25.2	Do.
25	1	83	16		6	6	....do.....	22.4	Do.

List of snags pulled out and cut up, &c.—Continued.

Date.	No. of snags.	Length of trunk.	Circumference of butt.	Circumference of top.	Kind of tree.	Estimated weight in tons, 2,000 pounds.	Locality whence taken.
1868.		*Ft.*	*Ft. In.*	*Ft. In.*			
May 25	1	45	15	5	Sycamore	9.9	Dozier's landing.
25	1	70	4 6	3	Hackberry	2.1	Do.
26	1	105	10 6	5 6	Sycamore	13.6	Do.
26	1	126	11 6	6	Cottonwood	20.2	Do.
26	1	51	11	7 6	Sycamore	8.7	Do.
27	1	50	16	8		15	Dozier's Bend.
27	1	83	7	3 6	Cottonwood	4.1	Do.
27	1	64	7	4 6	Sycamore	3.8	Above Dozier's Bend.
27	*1	104	17	13	do	47.3	Do. do.
27	*1	49	14 6	13	do	20.2	Do. do.
28	1	42	10 6	5 6	do	5.5	Do. do.
28	1	73	7 6	4	Elm	5.1	Abreast of Howell's island.
29	1	105	4	2	Cottonwood	2.1	Cashow's landing.
29	1	92	5 6	4	do	4.6	Do.
29	*1	90	4	2	do	1.8	Do.
29	*1	70	3	1 6	do	.7	Do.
29	*1	91	3 6	2	do	.9	Do.
29	*1	65	5	3	do	1.9	Do.
29	*1	93	5	3	do	2.7	Do.
29	*1	95	5	3	do	2.8	Do.
29	1	98	5 6	3	do	3.9	Abreast of Howell's island.
29	1	84	5 6	2 6	do	2.5	Do. do.
29	1	70	3	2	do	.9	Do. do.
29	*1	91	3	2	do	.9	Do. do.
29	*1	80	4 6	2	do	1.6	Do. do.
29	*1	70	4	1 6	do	1.4	Do. do.
29	*1	91	5	3	do	2.7	Do. do.
29	*1	105	5 6	2	do	3.1	Do. do.
30	*1	82	3	2	do	1	Do. do.
30	*1	135	8	3 6	do	10	Do. do.
30	*1	143	7 6	3	do	8.6	Do. do.
30	*1	71	4	1 6	do	12	Do. do.
30	*1	63	4 6	2	do	1.5	Do. do.
30	1	81	3 6	2	do	.8	Do. do.
30	1	110	11 6	7	do	18.7	Do. do.
30	*1	109	12	5	do	16.3	Do. do.
30	*1	105	11 6	3	do	11.5	Do. do.
30	1	101	7	2 6	do	5	Do. do.
30	1	89	14	9	Sycamore	15.9	Do. do.
30	1	91	9	4	Cottonwood	8.1	Do. do.
30	1	63	16 6	12	do	25.8	Do. do.
June 1	1	75	9	5	Sycamore	7.5	Dozier's Bend.
1	1	58	15	12	do	20.9	Do.
2	1	49	16	13 6	do	21.1	Missouriton Bend.
2	1	107	11	2	Elm	10 7	Do.
2	1	80	4	2 6	Hackberry	1.6	Do.
2	*1	98	16	10	Sycamore	33.3	Do.
2	*1	33	3	1 6	Elm	.3	Do.
2	1	92	15	7	Sycamore	23	Do.
3	1	71	6	2	Cottonwood	2.1	Do.
3	1	53	11	6	Elm	7.9	Do.
3	1	71	15 6	14	Sycamore	31.2	Do.
3	1	47	6	2	Cottonwood		Do.
3	1	108	9	3	do		Do.
3	1	156	9 6	3	do		Do.
4	1	43	9	3	Sycamore		Do.
4	1	114	9 6	3	Cottonwood		Do.
4	1	84	12	9	Sycamore	18.5	Do.
4	1	53	12	9	Cottonwood	11.7	Do.
4	1	93	14 6	10	do	27.9	Hinman's Point.
5	1	116	15	10	do	37	Do.
5	1	80	11	9		16	Do.
5	1	59	11 6	9	Sycamore	12.4	Augusta Bend.
5	1	64	12 6	9	do	14.7	Do.
6	1	30					Kurtlebaum's landing.
6	1	49	15 6	10	Sycamore	16.2	Augusta Bend.
6	1	86	14	12 6	do	30.1	Do.
8	1	62	16	13	do	26	Above Augusta, Missouri.
8	1	69	10	8 6	Elm	11.7	South Bend.
8	1	56	15	9	Black walnut	16.2	Do.
9	1	48	12	9 6	Elm	11	Do.
9	1	98	12	9	Sycamore	21.6	Do.
9	1	57	13	9 6	do	14.8	South Point.
10	1	99	13	6	do	18.8	Abreast of St. John's island.

* Pulled together.

List of snags pulled out and cut up, &c.—Continued.

ie.	No. of snags.	Length of trunk.	Circumference of butt.		Circumference of top.		Kind of tree.	Estimated weight in tons, 2,000 pounds.	Locality whence taken.
		Ft.	*Ft.*	*In.*	*Ft.*	*In.*			
10	1	57	6		2		Cottonwood ...	1.7	Abreast of St. John's island.
10	1	51	9		5		.....	5.1	Head of St. John's island.
10	1	57	11		4		Elm.....	6.8	Do. do.
10	1	90	13		12		Sycamore	27.9	Do. do.
10	1	.....	.....		.....		.....	.....	Do. do.
11	1	25	6	6	5	6	Sycamore	1.7	Do. do.
11	1	45	12		6	6	....do.....	7.6	Do. do.
11	1	28	9		6		Elm.....	3.1	Do. do.
11	1	39	10	6	8	6	....do.....	7	Do. do.
11	1	57	9		8		....do.....	8.5	Do. do.
11	1	63	6		2	6	Cottonwood ...	2.5	Do. do.
11	1	117	14		6		....do.....	24.6	Emily's Bend.
12	1	38	3	6	1	6	....do.....	.6	Do.
12	1	106	13		1		Sycamore	17.7	Do.
12	1	111	10		2		....do.....	8.9	Do.
12	1	93	12	6	3		Elm.....	12.1	Do.
12	1	97	18	4	9		Cottonwood ...	37.8	Do.
13	1	89	7	6	2		Elm.....	4.4	Three miles below Miller's landing.
13	1	18	5	6	3		....do.....	.7	Do. do.
13	1	29	6	6	2	6	....do.....	1.2	Do. do.
15	1	57	6	6	4	6	Cottonwood ...	3.4	Do. do.
15	1	48	8	6	7		.....	5.8	Do. do.
15	1	47	10		7	6	Sycamore	7	Miller's Bend.
15	1	61	13	6	11		....do.....	9.3	Do.
16	1	119	21		14		....do.....	73.8	Do.
17	1	78	12		8		....do.....	15.6	Do.
17	1	80	11		6		Elm.....	12	Do.
17	1	79	7	6	4		Sycamore	5.5	Do.
17	1	95	11		9		.....	19	Do.
17	1	89	6		2		Cottonwood ...	2.7	New Haven, Missouri.
17	1	78	10	6	2		Sycamore	7	Abreast of Pickney.
17	1	69	12		9		....do.....	15.2	Do. do.
18	1	39	12		6		Elm.....	6.2	Do. do.
18	1	83	5		6		Cottonwood ...	1.7	Do. do.
18	1	55	4	6	1		Hackberry	1.1	Do. do.
18	1	51	17	6	11		Sycamore	21	Do. do.
18	1	79	3	6	1		Hackberry	.8	Do. do.
18	1	41	9		5		.....	4.1	Pickney Bend.
18	1	53	11	6	7		Cottonwood ...	9	Do.
18	1	83	2			6	Elm.....	.3	Do.
18	1	32	2		1		Sycamore	.1	Do.
19	1	114	9			6	Cottonwood ...	6.8	Myers's landing.
19	1	108	12		1		....do.....	10.8	Myers's wood-yard.
19	1	96	14		5		....do.....	18.2	Do.
20	1	96	4	6	1		....do.....	1.9	Do.
20	1	69	11		5		....do.....	9	Do.
20	1	116	12		6		....do.....	18.6	Do.
20	1	88	9	6	2		....do.....	6.2	Do.
20	1	123	13		3		....do.....	17.2	Do.
20	1	87	10		2		....do.....	7	Do.
20	1	73	12		5		....do.....	10.9	Do.
20	1	102	13	6	5		....do.....	18.5	Do.
20	1	95	9	6	2		....do.....	6.6	Do.
20	1	129	14		5	6	....do.....	25.8	Do.
22	1	36	5		3		....do.....	1.1	Pickney Bend.
22	1	61	9		6		....do.....	6.7	Do.
22	1	84	4		2		....do.....	1.7	Myers's wood-yard.
22	1	98	13	6	6		Elm.....	19.6	Do.
23	1	69	6	6	2		Cottonwood ...	2.8	Do.
23	1	82	7		2		....do.....	3.3	Do.
23	1	86	9	6	2	6	....do.....	6.9	Above Myers's wood-yard.
23	1	101	11		3		....do.....	10.1	Do. do.
23	1	45	3			6	....do.....	.3	Head of White-house island.
23	1	89	17		7		Sycamore	26.7	Loutre island.
23	1	91	15		4		Elm.....	18.2	Do.
24	1	120	15	6	3		Cottonwood ...	21.8	Do.
24	*1 }	89	15		4		....do.....	17.8	Do.
24	*1 }	.....	.....		.....		Elm (small) ...	.....	Do.
24	1	69	11		8		Sycamore	12.4	Do.
24	1	75	6		1	6	Elm.....	2.2	Do.
24	1	85	17		2		Sycamore	18.7	Do.
25	1	77	9		3		....do.....	6.2	Do.
25	1	62	4		1		Black walnut ..	.6	Do.

*Pulled together.

List of snags pulled out and cut up, &c.—Continued.

Date.	No. of snags.	Length of trunk.	Circumference of butt.	Circumference of top.	Kind of tree.	Estimated weight in tons, 2,000 pounds.	Locality whence taken.
1868.		Ft.	Ft. In.	Ft. In.			
June 25	1	23	4	3	Sycamore	.5	Loutre island.
25	1	23	7	1	Elm	.9	Do.
25	1	114	17 6	5 6	Cottonwood ...	33.3	Head of Loutre island.
25	1	92	16 6	6	....do.....	24.8	Do. do.
25	*1	55	7	3	Elm.....	2.7	Do. do.
25	*1	55	7	3	....do.....	2.7	Do. do.
26	1	42	13	10	Sycamore	11.3	Loutre island.
26	1	61	6	4	Cottonwood ...	3	Do.
26	1	41	6	3	Sycamore	1.6	Do.
26	1	57	4	2	Elm.....	1.1	Do.
26	1	108	10	3	....do.....	9.7	Do.
26	1	47	6	2 6	Sycamore	1.9	Do.
26	1	68	15	10	... do.....	21.8	Do.
26	1	41	8	6	....do.....	4.1	Do.
26	1	78	13 6	8	Elm.....	18.7	Do.
26	1	47	2	6	....do.....	2	Do.
26	1	53	6	3	Cottonwood ...	2.1	Do.
27	1	54	13	10	Sycamore	14.6	Do.
27	1	65	16	13	... do.....	27.3	Do.
27	1	77	6	4	Elm.....	3.8	Do.
27	1	74	6	3	Cottonwood ...	3	Do.
27	1	101	6 6	6	... do.....	3	Do.
27	1	56	7	3	Sycamore	2.8	Do.
27	1	71	7	1 6	Cottonwood ...	2.8	Do.
27	1	49	4	6	....do.....	.5	Do.
27	1	39	6	2 6	....do.....	1.6	Do.
29	1	83	3	6	....do.....	.6	Mouth of Cole's creek.
29	1	72	15	8	Sycamore	19.4	Holser island.
29	1	55	13	9	Cottonwood ...	13.7	Above Mason's landing.
29	1	74	12	5	....do.....	11.1	Do. do.
30	1	98	16	9	....do.....	31.4	Do. do.
30	1	60	9	6	Sycamore	6.6	Gasconade Bend.
30	1	63	7 6	5	Cottonwood ...	5	Do.

*Pulled together.

RECAPITULATION.

Total number of snags, 222, weighing 2,486.2 tons, from commencement of work on the 11th May, 1868, to the end of fiscal year, 30th June, 1868.

K 11.

List of snags pulled out and cut up by United States snag-boat S. H. Long.

Date.	No. of snags.	Length of trunk.	Circumference of butt.	Circumference of top.	Kind of tree.	Estimated weight in tons, 2,000 pounds.	Locality whence taken.
1868.		Ft.	Ft. In.	Ft. In.			
April 25	1	97	21	10	Cottonwood ...	49.5	Head of Wabash island, Ohio river.
May 4	1	102	12	3 6	....do.....	13.3	Floyd Smith's landing, Arkansas river.
4	1	135	4 4	2 8	....do.....	6.7	Opposite Farley's old place.
5	1	136	11	7	....do.....	21.8	Foot of Moore's cut-off.
5	1	125	10 6	6 6	....do.....	18.7	Above South Bend postoffice.
6	1	120	17	9	....do.....	42	Bend below Dr. Price's plantation.
7	1	116	7 6	7 6	....do.....	12.8	Bend above Dr. Price's landing.
9	1	126	12 6	7 6	....do.....	25.6	Below Douglass's landing.
9	1	84	8 6	.....	.....	.....	Bend above Price's farm.
9	1	125	9	5	Cottonwood ...	12.5	Bend below Price's farm.
11	1	132	10	7	....do.....	18.5	Bend above South Bend.
11	1	155	11	7 6	....do.....	26	Do. do.
11	1	134	12	7	....do.....	24.1	Do. do.
12	1	116	9	4 9	....do.....	11.6	Do. do.

List of snags pulled out and cut up, &c.—Continued.

Date.	No. of snags.	Length of trunk.	Circumference of butt.	Circumference of top.	Kind of tree.	Estimated weight in tons, 2,000 pounds.	Locality whence taken.
1868.		*Ft.*	*Ft. In.*	*Ft. In.*			
y 13	1	101	12	3 6	Cottonwood . .	13.5	Below Floyd Smith's landing.
13	1	122	9	7	....do.....	15.9	Do. do.
13	1	123	9 6	4	....do.....	11.2	Do. do.
14	1	60	6	.....	....do.....	.....	Do. do.
14	1	123	20	10	....do.....	56.6	One mile below Floyd Smith's landing.
14	1	106	7 6	4	....do.....	7.4	Smith's cut-off.
14	1	92	11	4 6	....do.....	11	Do.
14	1	113	11	5	....do.....	14.7	Do.
14	1	105	8 6	4	....do.....	8.4	Do.
15	1	108	10	6	....do.....	13	Do.
15	1	125	12 6	8 6	....do.....	27.5	Do.
15	1	98	7	7	....do.....	9.7	Do.
15	1	70	12	7	Sycamore	12.1	Do.
15	1	84	7	4 6	Cottonwood ...	5	Do.
16	1	96	9	5	....do.....	9.6	Do.
16	1	151	9	6 6	....do	18.5	Do.
16	1	85	5 2	.....	....do.....	.....	Above Smith's cut-off.
22	1	55	5	.....	... do.....	....	Above Judlow's wood-yard.
22	1	35	5	.....	....do.....	.....	Do. do.
22	1	90	5	4	... do	2.7	Do. do.
22	1	95	4 6	3	Willow.....	2.8	Floyd Smith's landing.
22	1	80	7 6	4	Cottonwood ...	5.6	Bend below Silver Lake landing.
22	1	95	6 9	3	....do.....	4.7	Do. do.
22	1	95	6 9	3	....do.....	4.7	Do. do.
23	1	127	6	4 6	....do.....	6.3	Do. do.
23	1	128	10	8 6	....do.....	21.8	Head of Moore's cut-off.
23	1	128	12 6	10	....do.....	32	Oakley's Bend.
23	1	68	7	6	Maple	5.4	South Bend post office.
23	1	118	7	3 4	Cottonwood ...	5.9	Bend above South Bend post office.
25	1	53	6	5	....do.....	3.4	Marshall's wood-yard.
25	1	148	15	9	....do.....	43	Bend below Fairdale.
25	1	83	3	.....	....do.....	.....	Fairdale.
25	1	110	8 6	4 6	....do.....	9.9	Above Fairdale.
30	1	56	9	.....	Sycamore	.....	Douglass's landing.
30	1	82	8	7	Cottonwood ...	9	Bend bel'w Douglass's land'g.
30	1	85	8	4 6	.....	6 8	Watkins's landing.
30	1	75	4	3	Willow	1.5	Do.
0 1	1	123	8	6	Cottonwood ...	12.5	Silver Lake landing.
1	1	110	8 6	6	....do.....	11	Do. do.
1	1	126	12	10	....do.....	30.2	Do. do.
1	1	152	11	6	....do.....	24	Do. do.
1	1	126	8	6	....do.....	12.6	Do. do.
2	1	136	8	6	....do.....	13.6	Do. do.
2	1	124	15	9	....do.....	36	Above Silver Lake landing.
2	1	.....	.....	.....	.....	.....	Do. do.
2	1	132	9	5	Cottonwood ...	13.2	Do. do.
2	1	125	6 6	3 6	....do.....	6.2	Do. do.
2	1	130	6	4 6	....do.....	6.5	Do. do.
3	1	100	9	4 6	....do.....	9	Refeld's landing.
3	1	100	8	.....	....do.....	.....	Do.
3	1	65	8	4 6	Sycamore	5.2	Do.
3	1	115	12	6 6	Cottonwood ...	19.5	Do.
3	1	60	7	3	....do.....	3	Silver Lake landing.
4	1	130	8 6	6	....do.....	14.5	Smith's cut-off.
4	1	74	7	3	Willow.....	3.7	Do.
4	1	54	6	3 6	....do.....	2.2	Do.
4	1	113	8	5	Cottonwood ...	10.2	Arkansas Post.
5	1	53	6	3 6	....do.....	2.6	Above Red Fork.
5	1	65	6 6	4 6	....do.....	3.9	Five miles below Red Fork.
5	1	125	12	7 6	....do.....	23.7	Do. do.
5	1	93	4	2 6	....do.....	1.9	Head of White River cut-off.
5	1	127	13	9	....do.....	31.7	Do. do.
6	1	100	16 6	12	....do.....	40.7	White River cut-off.
6	1	90	12	8 6	....do	18.9	Do. do.
6	1	90	9	5	....do.....	9	Do, do.
6	1	106	8	3	....do.....	6.4	Do. do.
8	1	94	7	3	....do.....	4.7	Do. do.
8	1	82	.....	.....	....do..(small)	.....	Do. do.
8	1	125	8	4 6	....do.....	10	Do. do.
8	1	135	13	10 6	....do	37.8	Do. do.
8	1	105	15 6	9	....do.....	31.5	Do. do.
8	1	95	6 6	3	Hackberry ...	4.7	Above White River cut-off.
9	1	118	9	5	Cottonwood ...	11.8	Do. do.
9	1	148	9	5	....do.....	14.8	Do. do.

List of snags pulled out and cut up, &c.—Continued.

Date.	No. of snags.	Length of trunk	Circumference of butt.	Circumference of top.	Kind of tree.	Estimated weight in tons, 2,000 pounds.	Locality w
1868.		*Ft.*	*Ft. In.*	*Ft. In.*			
June 9	1	124	20 6	11 6	....do.....	65.7	Above White
9	1	97	14	8	Cottonwood ...	24.2	Do.
9	1	41	4 6	3 6	....do.....	.....	Do.
9	1	33	.....	.....	....do.....	.....	Do.
9	1	136	10 6	4 6	....do.....	16.3	Near Red Fo
9	1	115	3	.....	Sycam'e.(small)	.....	Do.
10	1	55	4	3	Cottonwood ...	1.1	Do.
10	1	132	17	9 9	....do.....	47.5	Do.
10	1	47	9	5 6	....do.....	5.2	Do.
10	1	75	8	5 6	Willow.....	6.7	Above Fletcl
10	1	110	10 6	7 6	.....	18.7	Do.
10	1	71	12	7 6	.....	13.5	Below Red F
11	1	56	10 6	6 6	.....	8.4	Do.
11	1	76	6 6	3	Gum	3.8	Do.
11	1	120	8	6 6	....do.....	13.2	Do.
11	1	95	12 6	6 6	Willow.....	18	Do.
11	1	58	.....	.....	Swamp ash....	.....	Do.
11	1	47	8	4 6	Willow.....	3.8	Do.
11	1	.....	8	3	.....	.....	Do.
11	1	130	9	5	.....	13	White River
12	1	85	10	6	.....	11	Do.
12	1	.....	8	5	.....	.....	Do.
12	1	96	9	4 6	.....	9.6	Do.
12	1	112	10	5	.....	13.4	Do.
12	1	75	8	5	.....	6.7	Do.
12	1	129	10	6	.....	16.8	Do.
12	1	100	16	9	.....	32	Do.
13	1	100	9	3 6	.....	9	Do.
13	1	117	9 6	5 6	.....	12.9	Do.
13	1	140	12	7	.....	25.2	Do.
13	1	117	7	3	.....	5.8	Above White
13	1	152	9 6	5	.....	16.7	Do.
15	1	75	4	2	.....	1.5	Notrebe's Be
15	1	81	9	4 6	.....	8.1	Foot of Smit
15	1	48	9	6	.....	5.3	Do.
15	1	52	6	3	.....	2.1	Do.
15	1	130	10	6	.....	16.9	Head of Sml
15	1	55	6	4 6	.....	3.3	Do.
16	1	170	15 6	9	.....	51	Mixture's Poi
17	1	72	9	7	.....	9.4	Below Booty
17	1	102	21	11	.....	53	Do.
17	1	130	9	4 6	.....	13	White River
17	1	93	7 6	5	.....	74	Do.
17	1	55	18	11	.....	22.1	Do.
20	1	30	3	3	.....	.6	Do.
20	1	120	11	7	.....	19.2	Above White
20	1	70	6	2	.....	2.1	Do.
22	1	123	13	6 6	.....	24.6	Ozark island.
22	1	144	17	7	.....	43.2	Head of Ozar sippi river.
22	1	104	17	6 6	.....	30.2	Do.
22	1	141	14	6	.....	29.6	Do.
23	1	147	12	8	.....	29.4	Bend of 71, C
24	1	125	23 3	13 6	.....	85	Do.
24	1	85	11	6 9	.....	13.6	Head of No.
24	1	132	13 6	7 6	.....	29	Bend of No.
25	1	109	11	6 6	.....	17.4	Head of No.
25	1	126	13	6 6	.....	25.2	Head of No.
26	1	100	13	8	.....	23	Do.
27	1	92	12 6	7	.....	17.5	Do.
29	1	147	19	8	.....	57.3	Bend of No.
29	1	137	21	8	.....	61.6	Do.

RECAPITULATION.

Total number of snags, 149, weighing 2,291.3 tons, from commencement of work on the 25 to the end of fiscal year, June 30, 1868.

K 12.

List of snags pulled out and cut up by United States snag-boat J. J. Abert.

ate.	No. of snags.	Length of trunk.	Circumference of butt.	Circumference of top.	Kind of tree.	Estimated weight in tons, 2,000 pounds.	Locality whence taken.
1868.		Ft.	Ft. In.	Ft. In.			
rch 28	1	85	16	12 5	Sycamore	34.8	Foot of Able's Towhead.
30	1	70	11	5	Elm	10	Do. do.
30	1	90	10	6	Cottonwood	11.7	Head of do.
31	1	.....	.....	.....	Large tree	.....	3 miles above do.
pril 1	1	120	14 7	8 6	Cottonwood	32.5	Head of do.
2	1	73	13	9 7	Sycamore	19	2 miles above do.
2	1	.....	.....	.....	Cottonw'd, sm'l.	.....	Do. do.
2	1	.....	.....	.....	Sycamore, (l'ge)	.....	Do. do.
3	1	.....	.....	.....	Cottonw'd, sm'l.	.....	Do. do.
3	1	.....	.....	.....	Bl'k waln't, sm'l.	.....	Foot of Dog Tooth Bend.
3	1	.....	.....	.....	Sycamore, sm'l.	.....	Do. do.
3	1	80	7	.....	Cottonwood	.....	Head of Dog Tooth island.
3	1	110	9	3	... do	8.8	Opposite Brook's Point.
4	1	85	11	6	Sycamore	12.7	Foot of Goose island.
4	1	.....	.....	.....	.....	.....	Head of do.
4	1	80	7	2 6	Cottonwood	4	Opposite Power's island.
6	1	70	9	5	....do	7	Do. do.
6	1	90	8	2	Sycamore	5.4	Foot of Birmand's island.
6	1	85	10	3	Cottonwood	7.6	Do. do.
6	1	.....	.....	.....	....do .. (small)	.....	Opposite do.
7	1	40	7	.....	Stump	.....	Foot of Rock island.
7	1	20	.....	.....	Stump	.....	Do. do.
7	1	63	12 6	9	Sycamore	14.5	Opposite Cape Girardeau.
8	1	104	19	10	....do	42.6	Devil's island.
11	1	130	19	10	Cottonwood	57	Do.
13	1	100	16	8	....do	30	Do.
13	1	110	16	6	....do	28.6	Do.
14	1	120	16	7	....do	32.4	Do.
15	1	110	14	7	....do	25.3	Do.
16	1	115	15	8	....do	31	Do.
16	1	.....	.....	.....	.....	.....	Do.
17	1	.....	.....	.....	....do	.....	Do.
18	1	.....	.....	.....	....do	.....	Do.
18	1	140	18	6	....do	43	Do.
20	1	170	15	6	....do	39.1	Do.
21	1	110	13	7	....do	23.1	Do.
21	1	115	13 6	5	....do	20.7	Do.
21	1	120	11	6	....do	18	Do.
21	1	110	11	5	....do	14.3	Do.
22	1	130	13	6	....do	24.7	Do.
22	1	110	16 6	8	....do	35.2	Do.
22	1	125	12	7	.....	22.5	Do.
22	1	65	7	5	Gum	4.6	Above Kinney's Point.
23	1	120	14	6	Cottonwood	25.2	Foot of Tower island.
23	1	110	8	5	Gum	8.8	Tower island.
23	1	90	11	7	Sycamore	14.4	Do.
23	1	110	15	6	Cottonwood	25.3	Head of Tower island.
23	1	135	12	7	....do	24.3	Do. do.
24	1	80	17 6	10	Sycamore	31.2	10 miles above Grand Tower.
24	1	90	9	5	Black walnut	9.1	Do. do.
24	1	110	13	8	Sycamore	25.3	Head of Hat island.
25	1	125	13	8	Cottonwood	28.7	Do. do.
26	1	90	11	8	Sycamore	16.2	Do. do.
27	1	110	10	8	....do	17.6	Below Devil's Backbone.
27	1	90	11	7	....do	14.4	Do. do.
27	1	50	15	10	....do	16	Below Liberty.
27	1	100	5	3	....do	3	Head of Liberty island.
28	1	90	9	6	....do	9.9	Below Chester, Ill.
28	1	95	15	8	Cottonwood	25.6	Do. do.
28	1	95	14	7	Sycamore	21.8	Do. do.
28	1	90	10	7	White walnut	12.6	Opposite Chester, Ill.
28	1	120	12	7	Sycamore	21.6	Below Dean's wood-yard.
29	1	.....	.....	.....	Bl'k waln't, sm'l.	.....	Do. do.
29	1	90	12	6	Cottonwood	14.4	Do. do.
30	1	103	10	5	....do	12	Fredman's wood-yard.
30	1	110	11	6	....do	16.5	Do. do.
30	1	80	8	5	Sycamore	7	Do. do.
30	1	35	15	.....	Cot'nw'd st'mp	.....	Do. do.
30	1	115	12	9	....do	25.3	Do. do.
30	1	100	13	9	....do	23	Do. do.
May 1	1	110	16	9	....do	35.2	Above Fredman's wood-yard
1	1	110	11	7	....do	17 6	4 miles above do.
1	1	120	15	10	....do	38.4	Do. do.
2	1	85	9	5	Sycamore	8.5	Kaskaskia.
2	1	90	6	3	....do	3.6	Below St. Genevieve, Mo.

List of snags cut up and pulled out, &c.—Continued.

Date.	No. of snags.	Length of trunk.	Circumference of butt.	Circumference of top.	Kind of tree.	Estimated weight in tons, 2,000 pounds.	Locality whence taken.
1868.		*Ft.*	*Ft. In.*	*Ft. In.*			
May 2	1	130	16	9	Cottonwood ...	41.8	Foot of Turkey island.
4	1	135	16	7	....do	36.4	Do. do.
4	1	135	14	5	....do	25.6	Do. do.
5	1	80	18	10	Sycamore	32	Head of do.
6	1	90	17	10	....do	33.3	Below Fort Chartres, Ill.
6	1	110	13	7	Cottonwood ...	23.1	Above do.
7	1	110	10	6	....do.....	14.3	Do. do.
7	1	90	10	5	....do.....	10.8	Do. do.
8	1	90	11	5	....do.....	11.7	Do. do.
8	1	100	12	5	....do.....	15	Do. do.
8	1	125	11	5	....do.....	16.2	Do. do.
8	1	120	11	7	....do.....	19.2	Do. do.
8	1	110	14 6	7	....do.....	26.4	Do. do.
9	1	95	9	5	....do.....	9.5	Do. do.
9	1	100	11	6	....do.....	15	Do. do.
9	1	115	16	9	....do.....	36.8	Do. do.
11	1	110	15	9	....do.....	31.9	Rush Island Bend.
11	1	95	13	9	....do.....	23.7	Do. do.
12	1	80	10	6	Sycamore	10.4	Rush Tower, Mo.
13	1	85	13	7	Cottonwood ...	17.8	Mouth of Merrimac river.
13	1	90	10	5	....do.....	10.8	Do. do.
13	1	110	13	9	....do.....	27.5	Do. do.
13	1	100	15	8	....do.....	27	Do. do.
14	1	85	7	5	....do.....	5.9	Above Smith's landing, Ill.
14	1	95	10	6	Sycamore	12.3	Arseland island.
16	1	112	15	10	Cottonwood ...	35.8	Liberty island.
16	1	105	10	5	Sycamore	12.6	Do.
16	1	70	9	6	... do.....	7.7	Balubridge landing.
18	1	55	11	7	....do.....	8.8	Head of Devil's island.
June 10	1	100	18	12	... do.....	44.9	Below Norfolk.
11	1	90	.....	.....	Cottonwood ...	.....	Do.
11	1	80	9	7	Sycamore	10.4	Do.
11	1	70	8	7	....do.....	7.7	Do.
11	1	50	6	5	....do	3	Do.
11	1	80	12	9	Elm.....	17.6	Putney Bend.
11	1	80	14	10	Sycamore	23.2	Do.
11	1	100	15 6	5	....do.....	22	Do.
12	1	110	8	6	Elm	11	Do.
13	1	135	16 8	12	Sycamore	55.3	Do.
13	1	130	14	4	Cottonwood ...	23.4	Do.
15	1	50	18	15	Sycamore	27	Do.
17	1	115	11	7	....do.....	18.4	Head of Island No. 2.
17	1	.....	.....	.....	....do .. (small)	.....	Do.
17	1	105	15	8	Cottonwood ...	28.3	Opposite do.
17	1	100	14	7	....do.....	23	Do. do.
18	1	125	9	7	Gum	16.2	Lucas Bend.
18	1	110	12	8	....do.....	22	Do.
20	1	.....	.....	.....	Cypress	.....	Foot of Lucas Bend.
20	1	.....	10	.....	Sycamore	.....	Do.
20	1	65	11	8	Pecan	7.7	Do.
20	1	95	9	7	Gum	12.3	Do.
20	1	95	9	7	....do.....	12.3	Do.
20	1	105	14	10	Sycamore	30.4	Foot of Wolf island.
22	1	80	9	8	Elm	12	Do. do.
22	1	60	10	8	....do.....	9.6	Do. do.
22	1	120	12	7	Gum	21.6	Below do.
22	1	115	12	7	Sycamore	20.7	Below Hickman, Ky.
22	1	75	16 6	12	....do.....	30.7	2 miles below do
23	1	.....	.....	.....	....do.....	.....	Do. do.
23	1	.....	.....	.....	Elder.....	.....	Do. do.
23	1	110	10	7	Gum	15.4	Head of Island No. 8.
23	1	90	12	8	....do.....	18	Opposite do.
23	1	120	11	7	Cottonwood ...	19.2	Near James's bayou.
23	1	120	13	7	Sycamore	25.2	Head Phillips's bar.
24	1	100	13	8	Gum	23	Do. do.
24	1	110	15	10	Cottonwood ...	35.2	Do. do.
24	1	80	10	7	....do.....	11.2	Foot of do.
25	1	120	10	6	....do.....	15.6	Do. do.
25	1	.....	.....	.....	....do.....	.....	Do. do
26	1	60	19 9	13 6	....do.....	33.6	Do. do.
27	1	110	18	12	....do.....	49.5	Below do.
29	1	.....	.....	.....	Gum	.....	Head of Island No. 10.
29	1	.....	.....	.....	Elm	.....	Do. do.
29	1	110	15	9	Sycamore	31.9	Do. do.
29	1	.....	.....	.....	Cottonwood ...	.....	Do. do.
29	1	100	12	7	Sycamore	18	Do. do.
29	1	.....	.....	.....	Cottonwood ...	.....	Opposite do.

List of snags cut up and pulled out, &c.—Continued.

Date.	No. of snags.	Length of trunk.	Circumference of butt.	Circumference of top.	Kind of tree.	Estimated weight in tons, 2,000 pounds.	Locality whence taken.
1868.		*Ft.*	*Ft. In.*	*Ft. In.*			
ne 29	1	75	12	10	Sycamore	18	Opposite Island No. 10.
30	1	100	13	10	....do.....	27	Foot of do.
30	1	.....	.....	.....	.....	.....	Do. do.
30	1	.....	.....	.....	Gum	.....	Above Point Pleasant, Mo.
30	1	95	12	8	Sycamore	19	Do. do.
30	1	.....	.....	.....	Cottonwood	.....	Above Tiptonsville.
30	1	120	11	9	Sycamore	24	Above Island No. 14.

RECAPITULATION.

Total number of snags, 158, weighing 2,708.4 tons, from commencement of work on the 28th of March, 68, to the end of fiscal year, 30th June, 1868.

K 13.

OFFICE OF WESTERN RIVER IMPROVEMENTS,
Cincinnati, Ohio, January 14, 1868.

GENERAL: I beg leave to lay before you the very able and interesting port of my assistant, Brevet Major C. W. Howell, captain of engineers, on the condition of the Missouri river, and his plans and estimates r improving the same, which I heartily approve, and trust that he may allowed to carry out.

It will be seen from this report that there is an immense field of opetions of more or less uncertainty as to the permanency of the improvent, although evidently very necessary to be undertaken, in the way removing snags; this part of the work it is expected to commence th one of our snag-boats now in the course of completion, whilst on e upper waters there is an opportunity and a demand for some work of more definite and permanent character of improvement in clearing the annel of boulders and in making some rock dams.

Major Howell's estimate for a suitable light-draught steamer, with quisite boilers, engines, tools, and machinery for the part of the work st alluded to, is $29,000; and for wages, &c., of crew for working the me, together with fuel, &c., for five months, $23,900; amounting to 2,900.

The money now remaining applicable to the Missouri river will afford ple means for defraying the above expense for the first season's work; d the future carrying on of the work would be the subject of new timates, made with the aid of the experience gained in working the at above estimated for.

As regards the work of snagging on the Missouri, the expense of that included in my annual estimates submitted on the 19th September, 67.

Should this report and recommendation meet with your approval, I g to be authorized as soon as possible to advertise for proposals for ilding, equipping, and furnishing complete, at some one convenient int on the Ohio river, such a light-draught steamer as is indicated in e general description given in the report.

The maps in progress for illustrating this report will be invaluable to

the engineer officer in charge of the party in the field to be improved, and it is expected to take tracings of them here on that account.

I remain, very respectfully, your most obedient servant,

J. N. MACOMB,
Colonel Engineers, Brevet Colonel U. S. Army.

Brevet Major General A. A. HUMPHREYS,
Brigadier General Commanding Corps of Engineers U. S. Army,
Headquarters, Washington, D. C.

P. S.—The report is mailed, in a separate package, in the same mail with this.

OFFICE WESTERN RIVER IMPROVEMENTS,
Cincinnati, Ohio, June 24, 1867.

SIR: You will proceed without delay to St. Louis, Missouri, and from that city, by river, to Fort Benton, for the purpose of inspecting the condition of the Missouri river with a view to its improvement.

You are authorized to employ one assistant to accompany you, and make as complete and accurate a sketch of the river as practicable, to illustrate your report.

On completion of this duty you will return to Cincinnati, and make to this office a detailed report, in writing, embracing all information of importance you may have gained.

You will pay particular attention to the obstructions in the river, including snags, bars, and rapids, and report on the feasibility of removing them, together with approximate estimates of time, labor, machinery, and expense necessary to render navigation more safe and speedy.

I remain, very respectfully, your obedient servant,

J. N. MACOMB,
Colonel Engineers, Brevet Colonel U. S. Army.

Brevet Major C. W. HOWELL,
Captain Engineers United States Army.

OFFICE WESTERN RIVER IMPROVEMENTS,
Cincinnati, Ohio, December 3, 1867.

COLONEL: In continuation of the duties designated in your order, dated June 24, 1867, I have the honor to submit the following report:

The maps and sketches intended to accompany this report are not yet completed, but will be forwarded the latter part of February, 1868.

I have the honor to be, sir, very respectfully, your obedient servant,

C. W. HOWELL,
Captain Engineers, Brevet Major U. S. Army.

Colonel JOHN M. MACOMB,
Corps of Engineers United States Army.

The Missouri river, owing to the rapidity of its current and the geological characteristics of its immediate valley, is at all times, after leaving the high-lands, 400 miles below Fort Benton, a wide and comparatively shallow stream.

The average velocity of its current has been estimated at three miles *per hour*, and this is very greatly increased during the flood season; in

contracted portions of the river frequently reaching five or six miles per hour, and forcing the most powerful steamers to use the towing line.

The immediate valley of the river presents the same general characteristics throughout the greater part of its length. The stream winds through a narrow bottom of light alluvial formation, closely shut in by high rounded hills or rolling table-lands, cushioning the bends and throwing the current from side to side across the valley. A luxuriant growth of cottonwood, interspersed at points with ash, elm, plum, and cherry, covers the most fertile portions of the bottom, while dense willow tickets fringe the lower banks, and creep out upon the long sand-points and higher bars.

The barren plateaus, which often intervene between the bottoms and the base of the hills, support but a scanty covering of coarse, short prairie grass and stunted sage brush, and the short narrow ravines furnish a straggling growth of pine and cedar.

These characteristics, though generally pertaining, are greatly modified in that portion of the valley below Fort Randall, at which point the bottom lands begin to widen and increase in fertility, and civilization adds its changes to the general features of the country. Cottonwood groves continue to hold their places on the lower grounds, but the hill-sides gradually exchange their nakedness for a valuable covering of oak, hickory, and walnut.

The light, loosely aggregated character of the bottom formation renders it peculiarly susceptible to the action of the current, which at all stages of the river cuts its way into exposed banks and fills the channel with the débris.

Even the more substantial bluffs are not exempt from the encroachments of the river when in flood, being subject, by their non-homogeneous formation, to the undermining action of the current which, washes away the layers of drift and precipitates the rock into the channel, always at such points running close in shore.

From the Round Bute to St. Louis every bend of the river gives more or less emphatic evidence of this cutting action, the bed of the river at peculiarly susceptible points shifting in a few weeks from 200 to 300 yards into the bottom lands, and frequently cutting through the necks of bends, changes the whole channel for miles on either side.

The disproportion between the current velocity and the stability of the banks causes the obstructed condition of the lower river. During the height of the flood season, but more particularly at a medium stage, the current cuts material from the bank faster than it can remove and arrange it; the water, already charged to the extent of its carrying power, rolls the suplus along the bottom, fills up the low-water channel, and evenly raises the river bed throughout its length and breadth; as the river falls below its medium height, work is gradually transferred from the bank to this accumulation of sand and mud upon the bottom; the two are sorted by the current, the mud carried away and deposited in the stiller portions of the stream to form the top-dressing of a willow bar or bottom, and the sand, left without its sedative influence, is shifted from place to place by the erratic efforts of the water, while accommodating itself to a channel. In consequence the whole bed of the river is choked by shifting sand-bars, giving one day a good channel and the next changing so as to obstruct the whole water-way; every change in the stage of the river, and every modification in the shape of its banks, either by cutting or filling, changes the direction of the current and forces a corresponding change in the sand deposits, so that these latter are never at rest, since the causes of disturbance continue throughout the year.

TIMBER DEPOSITS—DRIFT.

In addition to these sand obstructions others of a more dangerous character are formed, due to the same cause. By the caving in of timbered banks great numbers of cottonwood trees are precipitated into the stream, filling it with drift and snags. Trees washed in by the higher stages are generally carried to a distance before they are deposited; their roots are washed clear of earth; they are in consequence less liable to anchor in the bed of the river, and the majority of such are drifted on the bars and sand bottoms, where they dry and form the drift of succeeding floods. Drift, though at times dangerous, has its use, and the benefit derived from it in those stretches of the river where firewood is scarce more than counterbalances the risk of broken wheels and rudders, or the breaking of a few planks in a weak hull.

SNAGS.

Snags, on the contrary, are useless and extremely dangerous. They are to be found in every bend of the river, solitary or in clusters, standing out boldly above the surface of the water, or lurking beneath it with but a ripple on top to warn the pilot of their presence. Some have grown gray and lawn-like in their stations, while others, new comers, retain their limbs and stretch widely across the channel.

No portion of the river bed in the vicinity of timbered bottoms is without its snags. The newest are near the bank; the oldest have passed in turn across the channel and into the opposite growing point. The most dangerous are those old settlers in the crossings, where each season, as the channel shifts back and forth, they lie alternately in the channel or buried in the sand. The ice of each spring freshet, during a series of years, has added to their sharpness and curtailed their length till many of them only reach above the surface at low water; no pilot can tell their exact position, and to strike them is almost certain destruction. Many of them lie buried for years before the channel cuts around them; their place has passed from the memory of even those best acquainted with the river, and their presence is only manifested by the disaster they cause. The new comers are the least dangerous of snags; they are only troublesome; they block the channel along freshly cut banks and cause delay, but in time, as the bank cuts more and more, they are thinned out by the ice and by freshets, leaving the more stubborn to settle in the bars and wait the shifting of the channel to become, in their turn, dangerous.

In determining what snags ought to be removed to improve navigation only long experience should be consulted, and even that may often mislead. A cutting bank is always a good guide where the bends are deep and regular, for the channel usually runs close to it, but in long stretches or where islands divide the stream, only an experienced pilot accustomed to the river can tell where to clear the way. No certain estimate of the dimensions of a snag can be based on its showing above water; its inclination and the depth of water around it may in the majority of cases give an idea of its length, but not with certainty; many small appearing snags are but the limbs of large trees embedded in the sand, while those showing large diameters vary from 20 to 100 feet in length.

It will be safe to premise that all snags come from large trees, for only they have sufficient root to give a firm anchorage.

ROCK.

Rock obstructions occur wherever rocky bluffs border the stream, but *not in* troublesome numbers until entering the rapid section of the river.

A few disasters have occurred from their presence in the lower and middle river, but all from want of thorough pilots. Obstructions of this kind hold their place; do not occur where the channel is liable to shift, and for this reason can always be avoided with proper care and knowledge.

RAPIDS.

The rapids properly begin at Two-calf island, and are obstructed by rocky reefs, or, as in the majority of cases, by boulders congregated so as to partially dam the stream, rendering the channel tortuous and difficult. All of the rapids, even at low water, have a sufficient depth of water over the channel bed to carry boats adapted to the mountain trade, provided the channel be cleared of obstructions and several of the minor island chutes closed so as to throw the water into the main channel.

Throughout the rapids section the river bed is subject to but slight change; the channel does not shift; the water is free from sediment; the banks cut but very little, and are sparsely timbered; snags but seldom occur, and the bars, all of gravel, are permanent.

Between the rapids the channel gives from three to 10 feet water, and although studded with boulders, is perfectly safe when run with care. Between Two-calf island and Fort Benton there are 15 rapids, more or less difficult, the principal of which are Cow island, Snake Point, Dauphin's, Drowned Man's, and Marias. Should these five be well cleared, navigation will be insured until the 1st of October each season. The other rapids are simply difficult, not impassable, at any season. They are known as Two-calf, Bird, Bear, Lone Pine, Holmes, Pablos, Nos. 1, 2, and 3, and Kiddes.

The rapids are the only points above Fort Randall warranting improvement. That their improvement is of importance will be clearly proved by reference to the appended commercial statistics. The expense of improvement will be fully repaid the government in a single year by the decreased rates of freight incident to increased safety and certainty of navigation, and by dispensing with expensive wagon transportation from Cow island. The improvements necessary will be of the simplest kind, as shown by the following description and annexed sketches:

TWO-CALF ISLAND.

Two-calf island is at the foot of the rapids section. At this point the river is divided into three parts by two small islands, the greatest depth of water being found in the right and middle chutes, each about 40 yards in width and giving from three to six feet water. The middle chute, which is now the navigable channel, branches from the right-hand chute below the head of the larger island, and re-enters it before uniting with the left chute below. The water is deflected from its natural direction and thrown into this middle channel by a rocky bar formed across the right chute by the washings of a large ravine. Should this bar be removed and its cause guarded, the bulk of the stream would naturally seek the right shore and make a safe, deep, and permanent channel through the right chute, completely closing the middle one.

The middle chute branches from the right at such an obtuse angle that boats are obliged to send a hawser ahead, both in passing up and returning to prevent being driven on the bar and damaged. The left channel is never used except in high water.

TO IMPROVE TWO-CALF ISLAND.

To improve this point I propose the removal of the bar in the right chute, and that a boulder dam be thrown across the ravine 100 yards above its mouth to detain future drift from that quarter. Owing to want of time my observations were not sufficiently minute to warrant detailed estimates of time and labor required to make the proposed improvement, but approximate estimates will be found appended with sketch.

In passing up the next point worthy of improvement is the crossing at the head of Grand island. This is obstructed by a gravel bar extending across the main channel from Grand island to the foot of a small island above, and giving but 30 inches in the crossing. About one-fourth of the water is diverted from the natural channel by the two island chutes. If these were closed a fair channel three feet deep would be cut through the bar, and the troublesome suck through the Grand Island chute removed. The present crossing is very square, and after sparring over the bar boats are liable to swing into the head of the chute and ground, as did the steamers Miner and Only Chance on their second trip this season.

COW ISLAND.

At Cow island the river is again divided into three channels, the principal of these following the left shore and giving three, four, and five feet of water off the rocks. The only obstructions are loose boulders irregularly distributed over the bottom, and rendered troublesome by the rapidity of the current.

IMPROVEMENT.

To improve these rapids it will only be necessary to clear a direct channel through these boulders so that boats may keep head to the current in going up. With time further improvement might be made by closing the right chute, by which the left channel will be considerably deepened.

SNAKE POINT.

At Snake Point a ledge of rocks, with boulders lodged upon it, starting from the left shore, runs obliquely across the channel to the lower right-hand shore, having near its center a gap wide enough and deep enough for the passage of boats, but infested with boulders and oblique to the current, so that boats passing up are not only in danger of striking boulders in the gap, but are also in danger of swinging on the reef below. In passing down there is yet greater danger, and it is usual to drop through with bow and stern lines. By clearing the gap of boulders the channel will be made as good as in other portions of the river.

BIRD, BEAR, LONE PINE.

At Bird, Bear, and Lone Pine rapids a few boulders might be removed to the great benefit of those points; but I would not recommend work on them until more troublesome points are improved, since they can be safely passed, with proper care, at all seasons of the year when the other rapids are passable.

DAUPHIN'S.

Dauphin's rapids, the highest point on which I can report from personal inspection, is considered the most difficult of the series of rapids. It is the first to become impassable, and, except in very favorable seasons, is the terminus of the second trip of the season. But one boat of the mountain fleet passed it on the second trip this year, and she only succeeded after clearing a number of rocks from the channel, and sustaining very considerable injury about her hull. The river is here obstructed by a rocky chain across the channel, with loose boulders lodged above and below.

As with the other rapids, the plan of improvement proposed contemplates clearing a direct channel through these boulders and blasting through the reef. At the head of the rapids a small island divides the current, and both chutes have been used by boats; but from the best of my observation the channel along the left shore is best adapted to improvement, and may have all the water thrown into it by damming the right chute at the head of the island. By improving only this one point two trips from St. Louis to Benton will be insured to the regular mountain fleet each year.

OTHER RAPIDS.

Of those rapids above I can only report on information derived from others. Drowned Man's, and the rapids near the mouth of the Marias river, are considered the only points of real difficulty after leaving Dauphin's, and they are only represented as obstructed by boulders which, when removed, will leave a good channel.

BOAT FOR SERVICE IN CLEARING THE RAPIDS.

To effect the improvements above recommended to be made in the rapid section of the river, I would propose the building of a boat specially adapted to the service—a small side-wheel steamer with strong engines, and draught not to exceed 18 inches, strongly built forward to sustain a derrick capable of lifting ten tons, to be used in removing loose rocks; to be provided with tools for drilling rocks and materials for blasting; to carry a crew of from 15 to 20 able-bodied, intelligent men, and to be otherwise equipped as the most approved steamers of the mountain fleet. I annex details of a suitable steamer, drawn up and recommended by Mr. E. M. Shield, with estimate of cost of construction and working. With the steamer and crew proposed, all the necessary improvements can be made in a single season of three months, beginning on the 1st of July and ending on the 1st of October, and at an expense much less than would be warranted by the importance of the work.

SNAGS.

In consideration of the vastness of the work, even should it be deemed desirable, I would not recommend an attempt to clear the river of snags above Fort Randall. The vastly greater importance of the lower river and its more obstructed condition call for thorough and speedy attention, and is deserving of all the efforts that can be made to clear it. The yearly loss in this portion of the river from snags alone averages half a million of dollars, and injures the spirit of river enterprise to a much more serious extent. With two of the snag boats now in process of con

struction the channel may be thoroughly cleared of those dangerous obstructions in a single season from Randall to St. Louis.

The season favorable for operations begins about the middle of July, and continues until the middle of October, after which the river becomes so low that navigation is practically suspended for all except steamers of the lightest draught. For probable expense of a single season's operations I refer to annexed estimate.

Owing to the changeable nature of the river-bed and the continual additions of fresh deposits from cutting banks, it will be necessary to employ one boat during each season, for a number of years, on this duty, after which work may be suspended for a time, but must be resumed at intervals of a few years, so long as the importance of river transportation will warrant the expense.

WRECKS.

As might be expected from the character of the river, a great number of wrecks lie sunken in this lower section, but the great majority of them at present are not in the way, and pilots are familiar with their positions. Many of them have been partially removed by the underwriters, leaving but the hull and wheels, so that the labor of clearing them out of the channel has been greatly simplified. I would recommend the employment of the steamer Totten during the months of August and September, 1868, in the removal of those deemed dangerous or likely to become so.

BARS.

To free the river from the troublesome sand-bars which choke and complicate its channel for a distance of 2,500 miles, although practicable, would yet involve an outlay not warranted by the present importance of the stream. It would be necessary to protect the banks for that distance from the cutting action of the current, and to so confine the water way as to give a constant channel. This is of course not contemplated, and may never be deemed advisable.

Boats must clear their own way in the future as they have done in the past, but with better machinery. The old system of sparring, though generally achieving its purpose, is yet too clumsy and at times inefficient. A machine for ploughing through bars might be made as effective as the snow plow in use on our railroads, and even more effective, for the material of bars is of that kind easily moved by the current, and when slightly disturbed is quickly rolled away by the rush of water past the bows of a vessel.

SPARRING.

In sparring advantage is taken of this instability of sand-bars. The forward part of the boat is lifted bodily upon the bar, pushed forward by the engines and allowed to settle down upon the sand, the current rapidly washes underneath the hull, and the operation is repeated as fast as the spars can be taken up and reset. This mode is tedious and dependent on the height of the bar and velocity of the current but with ordinary bars, though slow, is successful when properly directed.

A light plowing machine in front of each boat with strong engines to push the vessel ahead would be more effective, more expeditious, less expensive, and less cumbersome, involving less wear and tear of tackle, and avoiding racking the hull.

FUEL.

This important item in the economy of the river is found in abundance between St. Louis and Fort Randall ready cut and dried for use. Wood-yards are at convenient intervals and prices reasonable. From Randall to Fort Buford firewood is scarce, although green timber exists in reasonable quantity. Boats depend for the greater part of their supply upon the drift found lodged upon points and bottoms; nomadic wood-choppers occasionally appear, but their tenure is too precarious for dependence, and steamers receive but little benefit from their services. Above Fort Buford, and until entering the rapids section, wood is abundant; large cottonwood deadenings presenting themselves at short intervals, and making excellent wooding stations.

COMMERCE.

The commerce of the Missouri, although not equal to the natural demands of the country dependent upon it, is steadily increasing in importance and will continue its growth to meet the necessities of our northern territories as their resources are developed, and navigation is rendered more safe and speedy. At present the commerce above the rapids is concentrated at the two ports, Camp Cooke and Fort Benton; the former receiving only army and sutler's supplies for the military post established there, and the latter receiving supplies for the mining country of Montana, for the military posts of Fort Benton and Sun river, and for the northern Indians.

During the season of 1867, 43 steamboats engaged in this trade cleared from the port of St. Louis; of these one made two round trips. Two on the second trip were unable to pass Dauphin's rapids, and left their freight at Cow island; one on the first trip could get no higher than Fort Hawley, and the steamer Imperial on the first trip discharged freight at Cow island, and is now on her return, last reported November 20, at St. Joseph, with 300 passengers and a large consignment of specie. The J. H. Prover was wrecked at Point au Poche, the Nora sunk near De Soto, the Deer Lodge had her shaft broken by drift near Decatur, and gave up her second trip.

Of the freight carried by this fleet 2,095 tons belong to government, and 5,966 to private parties, making a total of 8,061 tons dependent on the navigation of the rapids section of the river. Of the return cargoes I can give but little information. Hides, peltries, gold, silver, and copper are the only exports, and all seek river transportation.

It is safe to say that five-sixths of the mining products of Montana reach the east by way of Missouri river. The passenger traffic is also an item of considerable importance, and it is estimated that 10,000 persons during this season have taken this route to and from Montana, at an average rate of $150 each, making a total of $1,500,000 for payment of passages.

It is not expected that the river will in the future be the passenger route to Montana, for the reason that the trip can be made in much shorter time by the way of the Western Pacific railroad, and stage to the mines. Indian troubles may influence a few travelers, but the great majority will naturally seek the shortest and most speedy route, with its attendant risks. Travel from Montana in the spring and summer will, however, be by the river, the boats then being able to compete successfully in point of time with the stage route, besides furnishing a safer and more pleasant mode of traveling.

Nor does the river at present enjoy a monopoly of the Montana trade owing to the high rate of river transportation, the present uncertainty of navigation and insufficient number of boats employed.

It has been found necessary and economical to transport by wagon trains from Utah, California, and the terminus of the Union Pacific railroad, a large proportion of the breadstuffs and sundries consumed in the Territory.

By removing difficulties of navigation this trade will naturally be directed to the east. Rates will be reduced. A large fleet employed on the river and the prosperity of Montana and of the river interest, mutually dependent, will rapidly increase.

In view of this mutual dependence, projects have been set afoot, for railroad communication between Helena, the capital of Montana, and the river. A railroad from the mouth of the Muscle Shell river is deemed feasible, thus cutting off the rapids.

With the rapids improved, a railroad from Fort Benton would be desirable. Montana is a thrifty growing country, but its growth is greatly retarded by difficulty of communication. Even should it be attempted to overcome the difficulty, by a railroad from the Muscle Shell, or a branch from the Union Pacific railroad, years will necessarily elapse before such roads can be made of use, and in the mean time the Missouri river must retain its importance.

Taking such views of the case, I esteem the improvement of the rapids of the upper Missouri not only a necessity, but a duty the government owes to a Territory that promises to be one of our most flourishing States, and a portion of that mountain belt whose settlement will do more towards settling the Indian question than can be done by a powerful and expensive army.

In the middle section of the Missouri the ports are only at military or fur-trading posts, and are enumerated as follows: Fort Thompson, New Fort Sully, Fort Rice, Fort Stevenson, Fort Berthold, Fort Buford, and Fort Hawley. Consignments to these posts are either military supplies, Indian annuities, or the goods of fur traders. During the season of 1867 28 cargoes were cleared from St. Louis for these several points, amounting to 8,094 tons, of which government shipped 5,832 tons, and private parties 2,262 tons. The receipts from these ports are hides, horns, and peltries from the fur companies.

The number of passengers, though not great, is yet considerable, mostly officers and soldiers coming from and returning to their posts.

The lower section of the river, that is, from St. Louis to Fort Randall, has, of necessity, from the fact of its winding through a fertile and well populated country, the greatest commercial value, besides carrying all the commerce of the upper river; its own packet trade is perhaps as considerable as that of any western river, and its through trade from its great commercial center, St. Louis, though competing with railroad transportation, is of fair importance.

From the 1st of February, 1867, to the 1st of October, 1867, from St. Louis 212 clearances are recorded for this section, and 169 arrivals. Of the trade from St. Charles, Fort Leavenworth, St. Joseph, and other important points along the section, I am unable to furnish information further than to say that it is very considerable.

The government freight transported on this section amounted during the above eight months to 6,000 tons, and was consigned to Fort Leavenworth and Omaha.

For details of exports and receipts at the port of St. Louis I will refer to the tables annexed and furnished me by courtesy of Mr. George H. Morgan, secretary of the Union Merchants' Exchange, St. Louis.

For annexed list of government freight, I am indebted to Brevet Lieutenant Colonel C. W. Thomas, United States army.

Navigation opens on the lower Missouri on the breaking up of the ice about the last of February or the first of March, and continues good until the first or middle of September, when the river becomes so low as to cause great trouble from bars; boats, however, continue running until late in November, or in favorable seasons, until December, when ice closes the season. For the middle section the channel is good until the 1st of August above the Yellowstone, and until the middle of August below. From the latter period until the 1st of November the channel is full of bars and difficult. Boats have cleared from Fort Buford after the 1st of November, but at great risk.

In the upper section but little trouble is anticipated until the 1st of August; after that the rapids become quite impassable in ordinary seasons. The first boats for Fort Benton start from St. Louis the latter part of March, and encounter floating ice on the spring rise, above Randall. With boats specially built for the mountain trade, the up trip is made in 60 to 65 days, the return in 15 to 20 days. On the second trip the time to Benton ranges from 50 to 60 days.

During the last season many boats not adapted to the river attempted the trip to Benton and without success. The Centralia started June 12, and was 82 days in reaching Fort Hawley; 35 on return.

The Imperial started May 17th, and was 86 days in making Cow island; other boats made equally long trips. The increasing demands of the up river trade caused this addition to the mountain fleet, and has proven the impolicy of sending any but light draught powerful steamers to Fort Benton, except at the commencement of the season.

Parties interested in the upper river begin to recognize the necessity of a higher initial point than St. Louis. Sioux City will probably soon become the rendezvous of the mountain fleet, since from that point the trip will be much shortened, the dangers of the lower river avoided, and two round trips to Benton assured. Rates of freight and insurance will be greatly reduced, and the commercial interests of Chicago will come in direct competition with those of St. Louis, cheapening the value of goods to the consumer in Montana. Should it be decided to communicate with the river by wagon trains, at the mouth of the Muscle Shell, boats can make from four to five trips in a season, with ease, by starting from Sioux City, thus diverting the whole Montana trade to the river. The map of the river, now being made under my direction, will not be finished until late in February, when it will be submitted.

For details of my tour of inspection of the obstructions in the river, and of the river commerce, I refer you to the papers accompanying this report. For kind attention and material assistance in performing the duty intrusted to me I am greatly indebted to Captain Hawley and the officers of the steamer Miner.

For many civilities and much useful information, thanks are due to officers of the army stationed at the various military posts along the river.

In conclusion, I have the honor to be, sir, very respectfully, your obedient servant,

C. W. HOWELL,
Captain Engineers, Brevet Major U. S. A.

CINCINNATI, *November* 27, 1867.

SIR: In view of the requirement of boats having a light draught of water, and of sufficient strength to undergo the service of removing snags and other obstructions, I would recommend the following dimensions as suitable for such service, premising, however, that slight alterations may be found acceptable on the examination of the details of construction.

HULL.

Hull to be one hundred and thirty feet in length. Thirty feet breadth of beam, and five feet depth of hold; the bow of boat to be what is termed a scow, to rake twelve feet before intersecting the bottom of hull; the width of bow to be twenty feet of straight line, intersected by a curve of five feet of a side from the extreme breadth of beam; the stems of the bows to have a butting beam, sixteen by twenty inches, securely bolted and fastened, and the timbers of hull to come in union with the butting beam, and bolts running athwart ship to bind the same; three bulk-heads running the entire length of hull, and divided equally as to breadth of beam, and running longitudinally, connecting with butting beam in bow of boat. The hull will be decked in the usual manner of steamboats, but only a sufficient amount of guard projecting from hull to carry the wheels for the propelling of the boat.

MACHINERY.

The machinery will consist of two engines and a like number of boilers of such dimensions as may be found necessary for the proper propelling of the boat; two auxiliary engines, one of sufficient power to drive the hoisting apparatus located on the bow, which may consist of a crane or shears. The other engine will be applied to the capstan; the steam used for these engines will be taken from the boilers which are used for supplying the propelling engines.

CABIN.

The cabin will require length sufficient for the accommodation of the usual officers necessary to man the boat.

Your obedient servant,

E. M. SHIELD.

Major C. W. HOWELL,
Captain of Engineers U. S. A.

Monthly expenses of the mountain steamer Miner, Captain Hawley.

WAGES OF CREW.

Captain	$300 00
Mate	200 00
1 clerk	150 00
2 pilots	1,100 00
2 engineers	300 00
4 firemen	200 00
1 steward	290 00
1 carpenter	150 00
1 watchman	50 00

2 deck hands	$100 00
20 roustabouts, at $40	800 00
Wages of crew for one month	3,640 00
Stores, provisions, &c., $64 per day	2,240 00
Expenses, outfit, wear and tear, fuel, &c	890 00
Total	6,770 00

Five months, $33,850 less than pilots' wages.

Including 2 cooks, 2 cabin boys, 1 chambermaid, can be cut down to $30 when no passengers are carried; cut down one-half when no passengers, and with new boat, and with greater economy of fuel. Miner burns 30 cords cottonwood or 24 cords hard wood per day.

GEORGE SEAMAN,
Clerk of Steamer Miner.

Details of crew proposed on a steamer for improving the rapids of the upper Missouri.

Captain (an officer of engineers in charge of work.)	
1 mate, per month	$200 00
1 clerk, per month	150 00
2 pilots, per month	1,200 00
2 engineers, per month	300 00
4 firemen, per month	200 00
2 assistant engineers, per month	100 00
1 steward, 2 cabin boys, 2 cooks 1 chambermaid	300 00
1 carpenter, per month	150 00
2 deck hands, per month	100 00
15 roustabouts, at $40 per month	600 00
Total crew 32; total wages (one month)	3,300 00

C. W. HOWELL,
Captain of Engineers, Brevet Major U. S. A.

Estimated cost of building and equipping a steamboat for service in improving the rapids of the Upper Missouri river. Estimate made by Mr. E. M. Shield, principal assistant civil engineer western river improvements.

Building of hull and attachments	$9,000 00
Boilers, engines, and machinery	12,000 00
Cabin and joiners' work	3,000 00
Painting	1,000 00
Blocks and tackle, outfit of cabins, cordage, chains, &c	4,000 00
Total	29,000 00

Estimated cost of working the boat estimated above for five months.

Wages of crew	$16,500 00
Provisions	5,400 00
Fuel	1,000 00
Blasting powder	1,000 00
	23,900 00

Estimate of monthly wages of officers and crew of light-water snag-boat.

Captain	$150 00
Mate	125 00
Clerk	100 00
1st engineer	150 00
2d engineer	100 00
Assistant engineer and blacksmith	75 00
Pilot	300 00
Steersman	50 00
Carpenter	75 00
Steward	75 00
Cook	75 00
2 boys for cabin and cook house	50 00
Watchman	50 00
2 firemen, at $35 per month	70 00
8 deck hands, at $30 per month	240 00
	1,685 00

E. M. SHIELD.

June 28, 1867, 6 p. m.—In obedience to orders from Colonel John N. Macomb, corps of engineers United States army, dated office of Western River Improvements, Cincinnati, Ohio, June 24, 1867, I to-day started from Cincinnati en route for Omaha, Nebraska, via Chicago, Illinois. I is my intention to reach Omaha on the afternoon of June 30, in time to secure passage for Fort Benton, Montana Territory, on the steamer Deer Lodge, which leaves Omaha on the 1st of July. I have secured, as an assistant on the duties specified in my orders, Major F. Von Werner, a stranger to me, but having very complimentary letters of recommendation from several distinguished officers, under whom he served as a staff officer during the rebellion.

I have directed him to collect such instruments and materials as may be required for surveys and sketching, and with them to overtake me at Omaha or Sioux City, with as little delay as possible.

June 29, 1867.—I arrived in Chicago 1 p. m., and left via Chicago and Northwestern railroad 3 p. m., crossing the Mississippi river shortly after dark.

June 30, 1867.—Arrived at Ames station, Iowa, 8 a. m., and was detained to 1 p. m., awaiting repairs to a broken bridge, one mile west of station. Reached Council Bluffs 9 p. m., and owing to the high stage

of the Missouri could not cross during the night. I am informed that the river is over its banks at the usual ferry-landing, and ferry-boats only run during the day, landing five miles above the city.

July 1, 1867.—Arrived in Omaha 12 noon, two hours after the departure of the Deer Lodge, and from the best information I could gain, thought it best to await the arrival of the steamer Last Chance, reported due on the 2d or 3d.

July 2, 1867.—Omaha is a city containing from 8,000 to 10,000 inhabitants, and derives its importance from being the eastern terminus of the Union Pacific railroad. Its interests are sustained and forwarded by eastern capitalists and speculators, on the supposition that it will remain, at least for a number of years, the great entrepot for the commerce of the country west and north. It is at present a large depot for the supply of our troops on the plains, and enjoys a lucrative trade with the Territories of Idaho and Montana; receiving its supplies by rail from Chicago, and by river from St. Louis. It is rapidly increasing in wealth and population, but as there is no agricultural country to the west, on which it can depend, it can never expect to be more than a distributing point for eastern products, and will soon outgrow the limited demands for those. In case the railroad bridge across the Missouri is constructed at Bellville, fifteen miles below Omaha, we may expect to see the latter city sink to a second place as a commercial point, and gradually decay. The business portion of the city is built on the bluffs above overflow; the railroad, and buildings connected with it, are located on a sand flat beneath the bluffs, and at this time surrounded by water.

Not hearing from the Last Chance, I telegraphed to St. Louis for information, and on receipt of answer concluded to overtake the Deer Lodge, if possible, at Sioux City or Fort Randall. This is made possible by reason of the tortuous course of the river; the trip by boat consuming from three to four days, and by stage but 24 hours.

July 3, 1867.—Starting from Omaha 10 a. m., I arrived at Council Bluffs station 12 m., and at St. John's 1 p. m., where I took stage 3 p. m. for Sioux City, a distance of 100 miles. St. John's is a village of six months' growth, at the junction of the Sioux City branch of the Chicago and Northwestern railroad. The branch is but just commenced, but I am informed is being pushed rapidly forward, and will be completed during the coming winter, making Sioux City the most northern point on the Missouri river, having railroad communication with the east.

The stage road, after leaving St. John's, runs for 40 miles through a hilly country, sparsely settled and timbered; it then strikes the bottom lands below the mouth of the Little Sioux river, and does not again turn into the hills until reaching Sargent's bluffs, a few miles below Sioux City. Through the bottom lands the road is but a trail, and at many points is subject to overflow. The soil is a rich alluvion, well adapted to farming and grazing. The higher portions of the bottom are well timbered with a vigorous growth of cottonwood. On reaching the Little Sioux bottom, 9 p. m., I found the road flooded nearly to the top of the prairie grass for a distance of nearly five miles; the overflow caused by a storm above, conjointly with the high stage of the Missouri. By liberally feeing the drivers I induced them to attempt the crossing. The night was quite dark, and the road only indicated by the absence of grass above the water. In the middle of the swamp the driver lost the trail and mired the horses in a slough, and it was with great difficulty that we succeeded in extricating them, and recovering the road. At 4 o'clock on the morning of the 4th we effected the crossing.

July 4, 1867.—Arrived at Sioux City at 3 p. m., and found that I had

anticipated the arrival of the Deer Lodge, thus gaining time to form an estimate of the importance of the place.

Sioux City is a village of between 2,000 and 3,000 inhabitants, all thoroughly imbued with an idea of the future greatness of their town. It is located at the base of the hills above the mouth of the Floyd river, and the business portion is above overflow. The landing is good, but, owing to a large cut-off which occurred last spring a few miles above, is being slowly cut away, and unless protected will continue to cut for several years, probably forming a bar at the present landing.

The valleys of the Floyd and Big Sioux, together with the rich, wide bottom-lands on the west side of the Missouri, are tributary to the town, and when fully settled will sustain a thriving city.

While in St. Louis, last month, collecting information about the upper Missouri, I was informed that, except in extraordinary seasons, two trips to Fort Benton are impossible. It then appeared reasonable to suppose that owners of mountain boats would select some starting point higher up the river. Omaha at that time suggested itself, as the two round trips could be shortened from three weeks to a month. Yet, with all the enterprise and capital concentrated at Omaha, nothing of the kind has been projected, probably owing to the one absorbing idea, railroad.

I am now disposed to think that Sioux City is the proper point for concentrating the upper river trade. The completion of railroad communication with Chicago will bring that powerful rival in direct competition with St. Louis, and, aided by Sioux City enterprise—which can only expand in that one direction—we may expect to see, within the next few years, the trade of Montana and the upper Missouri passing from the grasp of St. Louis, and absorbed by Chicago capital invested in Sioux City.

By starting from Sioux city on the opening of navigation in the spring, boats can complete two round trips in the time now taken to make one from St. Louis, and return to Sioux city in the second, or, in other words, from five to six weeks less time than two round trips from St. Louis.

July 5.—To-day hear that the Deer Lodge broke her shaft below Decatur, and will return to St. Louis. I shall remain here to await the Last Chance.

July 6.—Joined by Major Von Werner.

July 7, 8, 9, 10, 11.—For Sioux city; Last Chance reported disabled at Little Sioux.

July 12, 10 a. m.—The steamer Miner, Captain Hawley, in the service of the Northwestern Fur Company, arrived at Sioux city, having cleared from St. Louis for fort Benton on the 29th June.

This boat having a good reputation for speed, comfort, and the uniform courtesy of her officers, I decided to secure passage on her for myself and assistant, although prepossessed in favor of the Only Chance, reported cleared from St. Louis on the 4th of July. Captain Hawley kindly afforded me every assistance in his power in furtherance of my duty, and placed at my disposal the best accommodations in the boat. We left Sioux city 10.30 a. m., and 2.30 p. m. stopped at Brazean's wood-yard, where half an hour was spent in wooding. We tied up for the night above Ponka 12 p. m. At Brazeau's wood-yard I found the river six feet lower than the highest flood-mark for this season. From the 1st to the 10th of July the river fell slowly. We are now going up on a very slight rise, probably due to a storm on some of the tributaries just above. I find the river at too high a stage to make a report on its condition of any value for future operations in clearing obstructions.

The snags visible are mostly on bars and sand points, and, although numerous, are not in the way of navigation. Those visible in or near

the course of the boat are to be seen at all stages of the river, and are, in consequence, not dangerous. The channel is at present so wide that boats can choose their way. It is only when the channel becomes contracted, (at low water,) and boats are forced to seek the deepest water, that snags become very troublesome and cause disaster or delay.

On the up trip I shall confine myself to generalities, and on returning devote my attention to the obstructions, in that way getting the best information possible. I have stationed my assistant in the pilot-house with all the necessary materials and instructions for making a sketch of the river.

July 13.—Started 3 a. m. River full of drift, as it has been for the last four days. All the drift passed yesterday and to-day has been large timber, both dry and green. The maximum stage of the spring flood swept the bottom lands clear of smaller drift and placed it beyond the influence of succeeding stages. The present drift comes from the higher bars, where it was left by the water before the present rise, and from banks now being cut away. In every bend of the river the banks are now undergoing this slow but steady undermining process, and the large cotton-wood trees are one by one toppling into the stream, to anchor, if their roots are sufficiently loaded with earth; to drift on the bars, if not. The bottom lands thus far I have found quite well timbered, but it is worthy of note that the timber, though some of it large, is with few exceptions young and vigorous, even the dead timber showing that old age was not the cause of death. Lay for the night above Bone river.

July 14.—Started 3 a. m. and reached Yankton village 6.30 a. m. The river wide and clear, the drift less frequent. Lay up at 12.30 of the 15th.

The country passed during the day similar to that passed yesterday, but with, perhaps, less timber the bottom lands are sparsely settled, but fertile, judging from the fine looking cornfields.

July 15.—Started 4 a. m., arrived at Yankton agency 7 a. m. and at Fort Randall 12 noon, where we lay two hours. Lay up for night 20 miles above, and for the first time on the trip were obliged to cut wood for use of the boat. During the day observed the bottom lands contracting, and timber becoming less abundant. At the mouth of the Niobrara and Ponka there are good bottoms, but above the farming land is confined to the east bank of the river. We are lying near the ranche of Major Hamilton, said to be the last farm we shall see in going up. The hills on either side are very regular in appearance, neatly rounded in outline, and covered with a short scanty grass, giving at a distance the idea of a well shaven rolling meadow, but when near at hand disclosing the barren soil, and looking dry and stinted. Timber is confined to the narrow bottom lands and islands, and to the short ravines occurring every few hundred feet. Cottonwood and cedar are the only species I could discover, the cottonwood choosing the low grounds, and the cedar growing in the ravines and on the larger islands. The island cedar is of a very fair growth, that in the ravines stunted, and in many instances deadened by the fires that annually denude the hills.

July 16.—After a good day's run lay up for the night at mouth of creek opposite Bijou hills. The river during the day full of islands, and no doubt bad in low water. Timber not abundant, but in sufficient quantity to meet the necessities of boats. Scrub-oak at several points. The cut bluffs expose a blue stratified rock, having the appearance of soft slate easily affected by the weather. The lines of stratification are nearly horizontal, and with frequent faults. Drift is becoming less frequent and the river falling slowly. Day clear and warm. Night close, and mosquitoes so annoying as to prevent sleep.

July 17.—Started at day-break, and late in the afternoon passed Fort Thompson without stopping, lying up for the night at St. John's wood-yard. Slate bluffs continue to bend above Fort Thompson, and there terminate. The fort is located above the entrance to the valley of Cow creek, on a wide open bottom land, from which the Santee Sioux manage to raise a scanty crop of corn; the fort is garrisoned by a single company of infantry for the protection of the agency. Wood scarce. Bottoms narrow, occasional narrow plateaus or prairie taking the place of bottom lands, many of the hills barren and topped with a dark-colored soil.

July 18.—Reached Old Fort Sully in the afternoon and spent the remainder of the day in wooding. The fort is the property of the North Western Fur Company, and was occupied until recently by the United States; it is now deserted, and the buildings being torn down for wood. We replenished our ice-box from a well stored ice-house near the fort. The hills in the rear of the fort are covered with cobble stones of all sizes, and although the same in contour as hills heretofore met are very different in formation, having a large proportion of gravel. Wood from this point to the mouth of the Yellowstone is reported very scarce; boats depend on getting what they use from drift piles and deadenings in ravines. Green cottonwood is the poorest of fuel, and even when mixed with dry wood does not generate steam fast enough to move boats against a rapid current. Fortunately for the interests of commerce each year the bars and various bottoms above detain enough drift to supply the wants of boatmen, but often detain it in inconvenient places. As the commerce of the river expands, wood-choppers will find lucrative employment in establishing wood-yards along barren reaches, and collecting drift at points easy of access.

July 19.—Reached New Fort Sully early, and remained until the morning of the 20th, discharging freight for the fur companies. We were obliged to land three miles below the fort, the landing near the fort being obstructed by a large sand-bar.

The location of the fort is not well chosen, and subject to severe criticism. The buildings are substantial, roomy, and comfortable. All are not yet completed, but probably will be before winter sets in. Wood can be obtained opposite and also a few miles above.

Lieutenant Walker, adjutant of the post, kindly offered to keep a gauge record, and collect information of interest as soon as men can be spared from work on the fort.

July 20.—Left New Fort Sully 12 noon, and lay up for the night near the mouth of the Big Shayenne. But little drift in the channel, and water falling slowly. Current very rapid. Noticed for the first time a growth of box elder. The Ida Stockdale passed down yesterday, and reported hostile Indians on the bluffs at the mouth of the Big Shayenne. It is a favorite place for attacking boats. The bluffs are high, and the channel runs under them; the assailants have good cover and a plunging fire. To guard against attack we placed semi-circular shields of boiler-iron six feet in height on either side of the wheel in the pilot-house, and constructed log breastworks along the forward guards of the boiler-deck and around the ash-pans and engines on the lower deck. Arms were all loaded and placed in racks at convenient places, and a small old-fashioned field-piece was placed in a conspicuous position on the forward boiler-deck. No danger has been apprehended below this point. Many boats after leaving Fort Randall take the precaution, when tied to the bank, of sparring off and mounting guard. We have tied to the bank every night and kept no guard but the regular watchman. Captain Hawley informs me, that he has never deemed greater precaution necessary.

July 21.—Run to small creek five miles above mouth of Little Shayenne, and tied up to right bank. Very good dry wood 200 yasds from boat. Were engaged in wooding until 12 p. m. Steamer Centralia 100 yards above us. She cleared from St. Louis June 12, 1867, loaded with army supplies for Camp Cooke, and has been delayed by reason of having pilots and captain unacquainted with the river, and in addition a mutinous crew of Irishmen.

The captain informed me that he had been burning green cottonwood, and that he could not make enough steam. We are now in the lower part of Swan Lake reach, known among river men as one of the most troublesome sections of the river at all stages. It is from 15 to 20 miles in length, and very much obstructed by sand-bars, making the channel tortuous and difficult to find.

I am informed that Irish crews almost invariably give trouble; they are clannish and unwilling to bend to the authority of the mate. When they work it is not with the alacrity desirable, and they seriously object to wooding in the night. Our crew of roustabouts is made up of negroes; they are always cheerful, obedient, and willing. When brought in contact with other crews, the contrast in the manner of working is greatly in favor of the colored crew. Our mate, who is an old river man, tells me that he has worked both white and black crews, and has a decided preference for the blacks.

July 22.—Started after sunrise, and passed Swan Lake reach with less trouble than apprehended. Once attempted a false channel, and were delayed an hour in sparring over a bar having on it three feet of water, the Miner drawing three and a half feet forward. This bar extended diagonally across the channel, and at no place gave a greater depth of water than three feet. Bars in straight reaches of this kind are subject to more frequent shiftings than in tortuous portions of the river, and only approximate to stability during low water. Lay up for the night below Fox island.

July 23.—Lay up at night and wooded at mouth of Bowerbenoc creek. River in excellent boating condition and falling. No detention during the day; channel well defined, running close inshore around the bends and making good crossings. Valleys of the Moreau and Grand rivers comparatively well timbered in the lower portions. Good grazing on the middle slopes; the lower bottoms thus far observed all present the same geological features. They have been formed by sand and mud deposits from annually recurring floods—the deposit aided by luxuriant growth of willows, incident to lands subject to overflow. The depth of successive deposits is well shown in sections by alternating layers of sand and mud; even the small deposits from secondary and tertiary overflows being well defined. Owing to this regularity of formation and cause, the ages of points and bottoms can be very accurately ascertained.

July 24.—Wooded and lay by during the night below the mouth of Battle creek. During the day took on board a deputation of Crow chiefs on their return to Milk river, where they expect to rejoin their tribe. They were sent to hold a council with General Sully, the Indian commissioner, but failed to overtake him, and are returning to their tribe very much dissatisfied. I am informed that the Crows are the best of up-river Indians, and uniformly peaceful, but that bad faith has been kept with them. They have three times sent deputations to hold council with commissioners, and each time the commissioners have been in too great haste to wait for them. The next commissioner will have to meet them in their own country, and not in the hostile Sioux country. River very good; banks cutting rapidly.

July 25.—Reached Fort Rice 4 p. m., and remained until next morning.

Landed near the fort inside the bar. The day has been sultry with indications of a storm; the river has been good during the day and has fallen slightly; dry timber has been scarce, and for the last three days we have been obliged to wood several times each day, and pick up such small supplies as we could find; green timber, though not abundant, is yet in sufficient quantity to furnish boats, provided wood-choppers could safely establish wood-yards. Several wood-yards have been attempted, but the Indians gave so much trouble that they were soon abandoned. The Indians attack the choppers, drive them to their cabins, and then fire the wood-piles. The territorial government also interferes by levying a heavy tax per cord, considered by those I have conversed with on the subject a species of black mail, and not sanctioned by law.

July 26.—Started at 3 a. m., and after running about 40 miles stopped to wood on right bank; on starting out again encountered a sudden and very severe storm and blow, which forced us to the bank for an hour, during which time a cottonwood tree of one foot diameter was blown across the boat in rear of the cabin, breaking our larboard hog-chains and crushing through a portion of the boiler deck. The storm ceased as suddenly as it began, and after clearing away the fallen tree we ran a a few hundred yards up the river, and tied up alongside a cut bank to repair. When we lay up the bank was cutting slowly, but soon began to fall in so fast as to make our position dangerous; tons of earth and willows falling frequently on the lower deck and threatening to sink the boat. We lay at this place for half an hour, when the small cottonwood to which we had tied 100 feet from the bank was washed in, and we were obliged to move to a better anchorage, which we found three miles above, where we lay for the night. As an instance of the instability of these bottom lands, I can cite nothing better than the above. The bank under which we lay was eight feet high and of the characteristic bottom formation, supporting a heavy growth of willows and young cottonwoods between five and six years old. On our arrival we found the current slowly undermining the banks; the presence of the boat caused a stronger current in the narrow chute between bank and hull and an eddy above. This slight change in velocity increased the rate of cutting a hundred fold.

July 27.—Although our repairs were not completed this morning, we were obliged to run higher for wood. This we found in the bight of the next righ-thand bend, where a large pile of excellent drift had lodged on the bottom. We lay by all day wooding and repairing the damage of yesterday. In the afternoon a hurricane came up from north-northwest and continued until late at night, with occasional lulls and heavy storms. At the wind was blowing us directly on shore no damage was done, although our chimney guys were strained at times to their utmost, and our pilot-house and cabin roughly shaken. The air was filled with clouds of sand, and the water was full of grasshoppers blown off shore. The waves during the night of the hurricane ran three and four feet high, and rapidly beat down exposed banks; a large quantity of green drift passed us during the day.

July 28.—Made a good run and lay up for night above Square Buttes, 20 miles below Fort Stevenson. Noticed coal at one point cropping out of the bluffs at the water's edge, but not in any quantity. Did not have time to examine it. Hills very bare; good grazing in the bottoms and larger ravines. Firewood continues scarce. River good.

July 29.—Started at 3.30 a m. and reached Fort Stevenson 6 p. m., landing under a cut bank and very good. The officers at this post report *plenty* of coal in the neighboring hills, but of a poor quality. It has been

used in stoves, but did not give entire satisfaction. It has also been used in the blacksmith shop, but did not give a good welding heat; it is a species of cannel. Stevenson is at present but an encampment; it is expected, however, that before winter fairly sets in buildings enough to shelter the garrison and stores will be finished. The quarters are to be of adobes with shingle roofs, and will present a very neat, comfortable appearance. The material for the adobes is found near the site of the fort, and when mixed with cut prairie grass promises to make very substantial walls. The bricks are made larger than usual, but dry well and retain their shape. The buildings will have stone foundations, and the walls will be strengthened by framing.

July 30.—Left Stevenson 3.30 a. m., and arrived at Fort Berthold 9 a. m., where we lay during the day and night, landing freight for the Northwestern Fur Company. At Berthold I found coal outcropping a few yards above the landing, and secured several specimens; it is a coarsely laminated lignite of a dark brown color, breaking into small fragments with irregular dull fracture when exposed to the air for any length of time, burning with a heavy yellow flame and smoke, and not possessed of great heating or illuminating power; the deposit exposed is in two seams, one of 10 inches thickness and the lower of three inches, conformably superposed on a bed of shale and covered with a compact gravel. In the hills back of Berthold I am informed this deposit has, for several years, been burning, and so near the surface as to cause the subsidence of many acres; (Major Galpin, Fur Company.) Wood scarce between Stevenson and Berthold. River good.

July 31.—Left Berthold 3.30 a. m., after a wakeful night spent in fighting mosquitoes. Lay during the night on a sand-bar in Great bend. Passed good timber at the mouth of the Little Missouri. Drift in bottoms scarce; dead timber becoming more frequent. Channel quite clear and of good depth. Noticed several outcrops of coal during the day, all having the same appearance as at Berthold, but showing larger seams and a greater number of them. In one cut bluff about 50 feet high I counted 17, three of about 18 inches' thickness each, separated by shale of about same thickness, and above them 14 at irregular intervals, ranging from one and a half inch to three inches in thickness. The seams might be worked to advantage.

August 1, 1867.—Started 3.30 a. m., and although detained by stoppages for wood, made a fair run, tying up at dusk to a sand point where we found a very fine drift pile. The hills have gradually lost that regularity of outline so familiar in that section of the valley above Sioux City, Randall and Sully, and now appear broken and frequently rocky. Sandstone of an indifferent quality and poorly cemented conglomerate alternate with the shales and frequently crown the bluffs; the immediate valley of the river is very narrow, rarely exceeding 2,500 or 3,000 yards, and presenting low plateaus and bottom lands in nearly equal proportion; the bends of the river in nearly all cases cut into the hills, making high steep-cut bluffs, with opposite narrow timbered points, concealing barren plateaus, outwardly bounded by bluffs and high table lands.

August 2.—Started at daylight, and without stoppage run until 3 p. m., when we encountered a violent wind storm, and were obliged to tie up fifteen miles below Muddy river, and lay by for the remainder of the day. The river continues at a good stage, though falling slowly. The general characteristics of the valley remain as yesterday. Coal occasionally appears, and breaks of boulders may be seen in the channel under rocky bluffs.

August 3.—Started at daylight, and without incident arrived at Fort Buford 5.40 p. m. On approaching the mouth of the Yellowstone the valley widens perceptibly, and the bottoms appear more fertile. The timber looks more vigorous and less scattered, the current is stronger, and the water-way has a more equitable width. The influence of the very rapid current of the Yellowstone, while gradually accommodating itself to the slower Missouri, is beneficial to the channel of the latter for a distance of nearly 100 miles below Buford; it then begins to deposit freely and spread out, forming at low water troublesome bars, with shallow chutes. Fort Buford is situated on the left bank of the Missouri. 12 miles below the mouth of the Yellowstone, and on a wide plateau about 20 miles long, and from 20 to 50 feet above low-water mark. During the winter of 1866–67 it was garrisoned by a single company, now increased to five companies. A new fort is now in process of construction to occupy a portion of the old site, to be much larger, and to be built of adobes. The timber for the new buildings will be obtained near the mouth of the Little Muddy, some 30 miles above. The adobes are made near the fort, and are of good quality.

Yesterday the Sioux made a raid on the cattle herd and killed several animals, but did no further damage, easily escaping from the infantry. Garrisons along this portion of the river are continually annoyed because of their inability to pursue Indian raiders. A company of cavalry at each post would be invaluable.

August 4.—Started from Buford at 8.30 a. m., and were three hours in reaching Fort Union. Started from Union at 1.30 p. m., and lay during the night about 30 miles above Fort Union is an old trading post, by land three miles above Buford. It will be dismantled shortly, and the traders removed to the latter place.

Found the river between Buford and Union very much cut up and difficult. Above Union quite good and with very few snags; the bed of the river much narrower, and the bottom lands wider. The bluffs are continuous on either side, running nearly parallel, touching the river only at each bend, and clearly defining the valley. Timber is not abundant, but the bottoms are full of young cottonwoods, giving promise in the future. I to-day left my assistant at Fort Buford, with orders to report for office duty in Cincinnati, preferring to sketch the remainder of the river myself.

August 5.—Started at daylight, and after a fair run lay up at 8 p. m. in bend above Poplar river, where we were stopped by a very difficult crossing. Were delayed for several hours in the forenoon by a difficult series of bends below and above Old Fort Kip cut-off. Although the cut-off occurred several years ago, the river has not yet accommodated itself to its bed, and in medium stage of water cuts into the bank so rapidly that the debris cannot be carried away by the already well charged current, and is consequently left to form troublesome bars in the channel and crossings.

The points are quite well timbered with cottonwood, and frequent deadenings at convenient landings supply the necessities of steamboats. Noticed during the day the ruins of several encampments, from which wood-choppers were forced last winter. Passed large herds of buffalo, the first seen this trip, and run into one herd crossing the river. The channel was so completely blocked up by the living mass that the boat was stopped to let them get out of the way. A number were carried under the hull and into the wheel, but cleared us without damage. The scene was one of great excitement, passengers and crew firing with such recklessness as to endanger their own lives to as great an extent as the lives of the frightened buffaloes.

August 6.—Were engaged from daylight until 6.30 a. m., sounding for a practicable channel, and at no place could find a crossing giving more than two feet, the steamer drawing 33 inches. At 6.30 attempted the lower channel, and after six hours' sparring crossed the principal bar, and ran into good water above, where we found the side-wheel steamer Viola Belle waiting for a channel to cut out, so that she could go down. She had been waiting three days. The Zephyr and Imperial bound up were delayed for the greater part of three days at this place sparring over. We lay for two hours one mile above bar and partially wooded, but finding timber very unhandy, 900 yards from boat, ran into next bend and found a fine deadening, where we lay for the night, and took in a good supply.

The sand of which these bars are formed is of the nature of quicksand. Iron and stone or other materials too heavy to be moved by the current sink below the surface of the sand in a few seconds; men or animals wading on the bars are obliged to keep in motion even on bars apparently dry. I yesterday saw Buffalo mired down to their sides, and exhausted by their efforts to get out. This characteristic of the bottom makes it simply necessary for a boat when working through a bar to push ahead with its spars, and keep in position so that the current may wash under and around it.

August 7.—Started 4 a. m., and entered a very troublesome part of the river known as Spread Eagle Reach, similar in every respect to the Swan Lake Reach below Fort Rice; we were five hours in making a distance of 10 miles. Above the Reach we ran into a series of very good bends, and with but a single delay of two hours, caused by taking a false channel, reached a fine deadening near the mouth of Porcupine creek, and lay up for the night. The part of the river run to-day is but little obstructed by snags, and is sufficiently well timbered to meet the wants of boats. Deadenings are of frequent occurrence and convenient for wooding; they are located on the higher portions of each point, and are said to be caused by fire, though they but seldom show traces of it. The great majority of the dead cottonwoods are stripped of bark, and are perfectly dry and sound.

August 8.—Started at daylight, and at 8 a. m. reached Milk river. Above Milk river found the channel very shallow and much obstructed. At 7 p. m. lay up above the mouth of Dry (Dorun's) Fork, having made but 15 miles in the last eleven hours. Were three times obliged to spar over bars giving but two and a half feet of water. The obstructions in this section are due to a cut-off which occurred several years ago in the bend above Milk river, by which two large bends have been obliterated. The bed of the river is now in a transition state, gradually working toward a natural shape; during high water the current cuts material for lower stages to carry off, and in consequence at a medium stage such as we now have, when the cutting and distributing powers are about equally balanced, this and similar parts of the river are in their least favorable condition for navigation. Landed our Crow passengers at Dry Fork to rejoin their tribe.

August 9.—Started 4 a. m., and till 4. p. m. had but little trouble. Not much water in channel, but the bends quite regular, and in consequence the channel well defined. Lay by from 8 a. m. until 12 m. for wood; 4.30 p. m. obliged to spar over a difficult bar, and in doing it broke a guy rope of derrick, and were detained by the accident until 6.30 p. m. After crossing the bar we ran until 9 p. m., when we lay up for the night. Passed several rocky bottoms during the day, but with good depth of water, and enough channel room to avoid boulders by running carefully.

August 10.—Started 4 a. m., and ran what is known as the Round butte, section beginning 15 miles below the butte and ending three miles above. We ran carefully, and without sparring cleared the Butte Bend 1 p. m. The channel is badly cut up by sand and gravel bars, with boulders in portions near shore.

The river throughout this section is wide and shallow, and the channel tortuous. After passing the butte, the valley assumed a character not before observed. The river winds in short regular bends through bottom lands ranging from half a mile to a mile in width, shut in by bold fancifully shaped hills bearing a stunted irregular growth of cedar and pine. The points are all well wooded midway to the hills; the banks are low and rounded, except in the bight of bends, where the current has cut into the base of the hills, and left perpendicular bluffs of from five to thirty feet in height. Sand points but seldom occur, and the few bars to be seen are formed near the middle of the stream. The river is very clear of snags, and the depth of the channel quite uniform.

There are but few signs of recent flood changes, and those but slight. At one point in a cut bluff, 25 feet high, saw a large cottonwood tree 18 inches diameter, half washed out by the last flood, showing that after the tree had obtained its present growth, the plateau on which it grew had received a deposit 15 feet in depth. The top was stunted and decaying, and trees having the same appearance were to be seen around it, and on all similar plateaus observed during the day. From the general formation of these plateaus, I am disposed to think that they were made by washing from the hills, and indicate a very rapid denudation, which gives to this portion of the river its stability by giving it firmer material for its bottom lands than the ordinary flood-deposit. Eight p. m. passed the steamer Zephyr bound up, and 8.30 p. m. tied up for the night, and wooded below Point au Poche.

August 11.—Started 4 a. m., and reached Fort Hawley 9 p. m., river continuing the same as yesterday. Plenty of good timber on all the points. Channel in mid-river nearly all day, frequent bouldered bottoms requiring care in passing them; width of river quite constant, ranging from 150 to 200 yards.

August 12.—Started 4.30 a. m., and without trouble reached Two-calf island 8 p. m. Tried to pass the right-hand chute, and found it closed at the head by a bar, giving only one foot water. So backed out, and lay up for the night. River same as the 11th and 12th, with the exception that the valley is more contracted, and timber is less abundant. Two-calf island is the beginning of the rapid section of the river. Passed the steamers Richmond and Guidon, bound down, below Harriott's island. Lay up from 12 m. until 6 p. m., above Harriott's, for wood; cut pine and cedar on the bluffs, and were obliged to carry it several hundred yards to the boat.

August 13.—Started 4.30 a. m., and passed up the middle chute at Two-calf island; obliged to get out cable, and pull over rapids at head of chute. Two and a half hours in passing the rapids; made slow progress against a very rapid current to head of Grand island, where we were obliged to spar over a gravel bar, giving two and a half feet water; made the crossing 1 p. m., and reached Cow island 5 p. m., where we lay up to sound the rapids for a channel; obliged to keep the lead going most of the time during the day; from three to eight feet in the channel; bottom rocky, bottom land very narrow, and covered with sage brush; good timber on Grand island; found three feet over the rapids in east chute, and would have no trouble in getting over if it were not for the boulders that infest the channel. Will have to pull over to-mor-

row. Laid a deadman on shore, above the rapids, to fasten our cable for pulling up. A deadman is laid in the following manner: a trench four feet long perpendicular to the line of torsion, and from two to three feet deep, is dug on shore, and a log of wood securely fastened on the bottom by stakes; to this log the towing line is fastened, and a small trench dug in the direction of the boat to accommodate the rope, and prevent a lifting strain. From this deadman a line is taken to the capstan.

August 14.—Passed the rapids 3 p. m., and lay up two miles above, at the terminus of the Fort Benton and Cow island wagon-road. With the present stage of water it is not considered probable that we can get above Dauphin's rapids. Captain Hawley has decided to leave his Fort Benton freight here, and attempt the upper rapids drawing as little water as possible. On our arrival we found the steamer Imperial lying at the bank, with all her freight ashore. She was obliged to double trip from Grand island to this point, drawing three feet, and was two days in passing Cow island. She cleared from St. Louis May 18th, drawing three and a half feet. During the night put our Benton freight ashore, and lightened to 26 inches.

August 15.—Started at 7 a. m., and at 11 a. m. had made six miles, when we were laid up for an hour by a wind-storm. After the storm we again pushed ahead, and tied up at night two and a half miles below Dauphin's rapids; found from three to four feet in the channel; found plenty of water over Snake Point rapids, and passed them without trouble, although for a moment in danger of swinging on the rocks and wrecking the boat. Channel much obstructed by loose rocks in the greater part passed to-day. Current very strong, wood very scarce.

August 16.—Started at 5 a. m., and at 8 a. m. tied up one mile below Dauphin's, having made one and a half mile in three hours. Careful sounding gave but 18 inches water over the boulders in the rapids, and three feet if they could be removed. The captain then decided to abandon the trip to Benton, and return to his freight above Cow island, rather than further risk the safety of his boat. At 7 p. m. we started on our return, and after making three miles tied up for the night. During the day I examined the rapids, and climbed to the top of the hills. A distance of two or three miles from the river I found abundance of excellent pine timber growing in the ravines and hollows. To the south I could see the Judith mountains and intervening ridges, apparently all well timbered.

August 17.—Started at daylight, and had no trouble until reaching Snake Point, where it was deemed necessary to get out bow and stern lines to drop the boat through. In executing this maneuver we grounded on a flat rock, and were delayed until noon before getting off. Two miles below Snake Point, in making a crossing, the current drove us on a gravel bar, where we lay all night. Everything movable on the boat was put ashore in yawls to lighten her, after which we took a cable ashore, and made ready to pull off in the morning.

August 18.—At 11 a. m., by pulling and sparring, succeeded in getting off the bar and taking wood and freight on board; reached our Benton freight pile without trouble at 1 p. m. The rapids I have had an opportunity to examine can be very much improved and rendered passable by simply removing the boulders in the channel; most of them can be taken out without blasting. Further improvement can be made by closing island chutes, thus gaining increased depth of channel and greater scouring power to the current. Improvements of the latter kind can be made permanent, and at small expense, as all the necessary material can be found at hand, *and much of it ready* for use.

August 19.—Spent the day among the hills to the south of Cow island, and in making a survey of the obstructions. Found plenty of good stone on the north bank, and plenty of good pine timber, convenient for use, on the south side. Game is abundant; a working party could easily supply themselves during the summer and fall without going many hundred yards from camp. Indians make their appearance but seldom. It is too far north for the Sioux, and the Crows are friendly, and have better hunting grounds. The steamers Only Chance and Zephyr passed the rapids this morning with but little trouble, but are double-tripping from Grand island. Only Chance discharged her freight, and returned to Grand island for remainder.

August 20.—Seven a. m. started down the river, and had no trouble until we reached the head of Grand island. There found the Only Chance hard aground in the head of the chute, having been carried there by the current after crossing the bar. In attempting to cross the bar too high up, we ran aground 10 a. m., and did not get over until 5 p. m. Ran until dark without further trouble.

August 21.—Started at daybreak, and 9.30 a m. arrived at Fort Hawley, a trading post of the Northwest Fur Company. Left Hawley 12 noon, and at 4 p. m. reached our wood-pile of the 11th, where we lay up for the night. During the afternoon we were greatly retarded by a strong head wind, which twice drove us into the bank, and twice set the boat on fire by sparks from the chimneys. The crew were engaged in wooding until 11 p. m. Since leaving Fort Buford we have been well supplied with fresh meat, principally of buffalo, deer, antelope, and wild geese. The country is full of game, and several of the mountain boats we have met depend so much on a good game supply, that they only bring as stores hard bread, hams, bacon, sugar, coffee, and a few cans of vegetables.

August 22.—Started at daylight, and at noon ran hard aground on a bar, nearly opposite Round bute. Put our wood and freight ashore with the boat's yawls, and after five hours' sparring, aided by a shore line. worked off and tied up for the night. Thus far down I have not noticed any perceptible change in the channel; just below, the channel through which we ran in coming up is completely filled, and a channel worked out on the opposite side of the river, giving two feet large in the shoalest place. The Miner is now drawing two feet scant, which will not be greatly increased by the little freight she expects between this and St. Louis.

August 23.—Started at daylight, and at 7 a. m. ran aground on a hard bar opposite Round bute. Again landed our wood and stores in the yawl, and tried to spar off, but without success, and finally laid a deadman on shore above us, and at 4 p. m. pulled off and reloaded. Made a short run, and without further trouble made a landing 10 miles below the bute; tied up for night, and wooded.

August 24.—Started at daylight, and without sparring reached a point two miles below Milk river, where we found a very bad crossing, and were obliged to lie up for the night and sound for a channel. Found the river from Round butte to Milk river greatly changed, and for the better. The majority of crossings are lower down than we found them on the up trip, and deeper; several bars have entirely disappeared, and no new ones found. The channel has now reached its low-water position, and unless shifted by a fall flood, will probably remain as at present until the breaking up next spring.

On the up trip I noticed a peculiarity of all wooded points, from the mouth of the Yellowstone to the Round butte, which proves a continual

shifting of the river bed towards its mouth. On the upper side of all points the banks are cut, and large cottonwoods are growing to the brink. In passing around the point, the cut bank becomes less and less in height, and the growth of timber gradually becomes younger, until the point culminates in a growth of willows, and beyond these plain sand. On the lower side of the point, until entering the bight of the succeeding bend, the shore slopes to the water with, first, a sand beach, then willows, young cottonwoods, old cottonwoods, and next the plateau's dead cottonwoods, in regular gradation of age; showing plainly regular denudation of the upper part of the point, and regular formation on the lower side. This gradual movement towards the direction of the current is also shown by the bluffs on either side; the whole line showing that at some time each portion of it has been subjected to the direct action of the river. The bearing of this characteristic on any plan of improvement is plain; showing that any improvement now made, unless it be for protecting the banks, for a few years hence will be on dry land.

August 25.—Started at 5 a. m., and in attempting to enter the chute, in rear of the island to which we tied last night, ran aground, and were swung around by the current so as to lie directly across the channel; as the width of the chute was a little less than the length of the boat, and as the current set in very strong, we found great difficulty in getting off, but succeeded after two hours' sparring, and had no further trouble of moment. The island and chute lie near the centre of Milk River reach, and the cutting of the channel at this point determines its characteristics through the reach. Should the channel choose the chute, the reach will be fair; but should it choose to cross the bar, it will continue bad quite through the bend below.

The channel through the reach we found tortuous, but regularly formed and good, giving three, four, five, and six feet of water. We stopped to wood about noon, and were detained two hours, after which we ran to Fort Charles bend, and at 4.30 p. m. lay up for the night alongside a good deadening. During the day saw thousands of buffalo and abundance of other game.

August 26.—Started at 5 a. m. and laid up at 4 p. m., on account of wind in bend below Elk Horn prairie. Had no trouble during the day; found three, four, and four and a half feet water over the worst crossings in Spread Eagle reach, and two and a half feet over crossing in bend above Poplar river. The crossing at this latter place, although the river has fallen about two feet, is nearly the same as we found it going up. It is in the same place, and has the same depth of water, but is not so tortuous. Two bends above Wolf Point are much obstructed by snags, but are cutting freely and shifting the channel.

August 27.—Started at day-break and reached Fort Buford at 6.30 p. m. Were delayed by a strong wind which sent us to the bank several times, but without damage. Below the Big Muddy, at several points, high, steep, rocky bluffs rise from the water's edge, and deposit dangerous rocks in the channel, which it would be desirable to clear. Coal makes its first appearance in these bluffs on the right hand side, and in fair seams. I am informed that these deposits of coal outcrop on the Yellowstone as far up as Powder river, and no doubt underlie the whole peninsula between the Yellowstone and Missouri. The buildings at Fort Union are nearly demolished, and the material taken to Fort Buford. The river between Union and Buford is very much cut up, but has fair water in the channel. The Yellowstone is very low, and at its junction with the Missouri falls about 18 inches in a distance of 100 yards, over loose rocks, and with a very rapid current.

August 28.—Started from Buford at 8 a. m., and at 12 m. were forced by a strong wind to tie up. Started again at 6.30 p. m., and at dusk lay by for night 20 miles below Muddy river. Channel fair and but little changed in the last month. But few snags, and those not large or troublesome. The river full of drowned grasshoppers.

August 29.—Started at daylight, and after a fair run lay up below Tide creek. After passing Little Knife river, found the channel full of bars and difficult; grounded several times, but were not greatly delayed, except by the necessity of running slow and sounding frequently. Day very warm and indications of a storm.

August 30.—Arrived at Fort Berthold 12 noon, and left 6 p. m., expecting to make Fort Stevenson before dark. Eight miles below Fort Berthold encountered a violent wind-storm; were driven to the bank, and were obliged to tie up for the night. The wind was so strong that birds left the trees and sought shelter in the underbrush. Just before dark one of our pilots caught a half-grown war eagle, who had sheltered himself in the bushes and could not rise from them. From Little Knife river to Berthold, the river is obstructed by bars and a few snags; below Berthold it is in better condition.

August 31.—Arrived at Fort Stevenson 8.30 a. m., and left 11 a. m. River improving, day cold, damp and windy. Four p. m., lay up below the mouth of the Big Knife river to wood, and remained during the night. Channel well defined and with good water. Not materially changed since going up, although the river has fallen about four feet in that time.

September 1.—Started 5 a. m., and without trouble reached Fort Rice 3.30 p. m. Here we expected to find 40 cords of good dry wood, cut and awaiting us, but were disappointed. The wood, though cut and well concealed, attracted the attention of another boat, and we reached the wood pile only in time to see the Centralia leaving with 30 cords on board, and Captain Hawley obliged to pay the bill at $8 per cord.

Left Rice 6 p. m. and ran below the Cannon Ball, where we spent the greater part of the night picking up drift.

September 2.—Started 5 a. m. and ran until 4 p. m., when we were forced by wind to lie up 40 miles above Grand river. Day raw and windy, with occasional drizzle. River good, and had but little trouble, only grounding twice, and both times sparring off with ease. In conversation with Major Galpin, one of the oldest fur traders in this country, and the best informed I have met, he expressed the desire of all those interested in the development of the upper Missouri valley for a thorough geographic and geological survey of the country drained by the Little Missouri, Heart, Big Knife, Cannon Ball, Grand, and Moreau rivers.

He has been over the greater part of the basin drained by those streams, and is impressed with its value as a grazing and mining country.

From his report I should judge a survey of importance in establishing future reservations for the Sioux Indians. I am informed that the climate is undergoing a gradual but marked change for the better, noticed even by those who have spent but a few years along the river. Rain is more frequent, vegetation more luxuriant, and winter sets in late, and in places cottonwood trees are giving way to ash and elms. Corn, potatoes, and oats, have been grown as far up as Fort Union, and although the stalks were stunted the grain was of fair size and quality. At Berthold I saw ears of corn six to eight inches in length, grown *on* stalks from 18 inches to 2 feet in height.

September 3.—Started at 5 a. m. and made a good day's run, tying up at 7 p. m. to right bank below Plum island, and 15 miles above mouth of Big Shayenne. River quite good with the exception of Swan Lake Reach, where we found the channel well cut but very tortuous. In passing the reach we were favored by a dead calm, which facilitated the handling of the boat, and enabled us by running carefully to keep the channel. Below the reach we were delayed an hour by taking the wrong outlet, but afterwards had no trouble. The bluffs passed to-day are based on a blue clay shale, crumbling where exposed, and easily blown down by wind. On the bluffs, under which we lay during the night, I found a group of syenitic boulders, some of them weighing as much as three or four tons. Wood scarce.

September 4.—Reached the Big Shayenne 9 a. m., and lay for night 10 miles below, having found a very bad river, much spread out and full of sand bars. Strong wind during the night, slightly abating before morning. Near this point, when going up, we found in abundance a plant used by the Indians to cure the bite of the rattlesnake. The stem is from two to four feet in length, and from an eighth to a quarter of an inch in diameter, the leaves long and slender, and from four to six inches apart, joining the stem along the line of a very oblique spiral. The stem is crowned by a yellow flower, about two inches in diameter, and having the appearance of a small sunflower. The root is long, and has but few ramifications. When stripped of its thick outer coating, it shows markings and color very much resembling the skin of the rattlesnake. My informant, an old hunter, who pointed out the plant, informed me that he had often seen it used, and with success. The person bitten chews a small piece of the root, swallows the juice and applies the pulp to the bite. The root has a pungent acid taste, but is not unpleasant. Dr. Kimball, United States army, stationed at Fort Buford, has a quantity of the plant, and will report on it to the medical department.

September 5.—Started 5 a. m., and reached Old Fort Sully 12 noon. Were several hours in passing Farm island. The day clear, but cool and windy. Run the channel to the right of Farm island, and were several times blown aground five miles below the island, and lay during the night on the bar. Steamer Last Chance overtook us, and lay during the night a few hundred yards above.

Farm island is considered one of the worst places on the river, as the channel shifts frequently from one side to the other. The buildings at Old Fort Sully are all torn down.

September 6.—Made about 15 miles, and lay up on account of wind. Channel fair, but the surface of the water so much broken by the wind as to make it difficult to determine its position. Day clear and cool.

September 7.—Were not able to start until 6 p. m. We then made five miles, and tied up for the night. Wind continuing. Plenty of water in the channel, from 3 to 10 feet, but the surface too rough to make the crossings. A stern-wheel boat is unmanageable in a high wind unless loaded down, and even then it is generally safer to tie up than to run. The wheel can only act in the direction of the boat's longer axis, and in consequence when moving obliquely to the wind the boat has a certain amount of lee-way for which there is no remedy, and she is blown on a bar in narrow crossings, or ashore in bends.

With a side-wheel steamer it is different, for the wheels can be used in steering, and become powerful aids to the rudder when used skilfully. The only objection to side wheels is the amount of drift met in the early and middle seasons, to which they are very much exposed, and from which stern wheels are in a measure protected by the hull.

September 8.—Started at daylight, and at 9 a. m. were blown ashore by the wind about 20 miles above Fort Thompson, where we lay until 4 p. m. The bluffs at this point are composed of alternating layers of sand, gravel, and clay shale; at their foot, and apparently coming from the gravel beds, I found large numbers of two casts (shell and reptile,) some of them having a metallic filling of a light reddish brown color, very finely granulated structure, and of such hardness as to scratch glass with as much ease as a diamond would. The cross-section of these reptile casts is an ellipse showing a vertebral joint, solid in the centre of the ellipse, and with six radical points running to the outer coating, which is a rich pearly covering, oak-leaf markings on the inner skin. I have found at this place, and at several points further up the river, a large number of these remains with metallic spar and claystone fillings; yet, although I searched diligently, could not find a head.

The diameter of those seen varied from one-fourth of an inch to one foot. One small specimen in my possession has become highly polished in the exposed point, and resembles polished copper. The shell casts are of sand and clay stone, some of them with the shell yet adhering.

Started again at 4 p. m., and at night lay up at right bank opposite Crow creek, with wind continuing strong.

September 9.—Ran well all day, and reached upper landing at Fort Randall point 5.30 p. m. The channel runs close to Randall Point, and is obstructed by loose rocks, causing a very stiff current around the point. At 6.30 we attempted to cross the bar opposite Randall, and ran hard aground. The bar washed from under us very rapidly, and at 12, midnight, washed us across where we lay until morning. An anchor put out above us in 18 inches of water, when raised in the morning, was found in a pocket six feet deep. This bar is a very troublesome one, and can only be remedied by clearing the channel at the point above, and throwing the water in bulk to the left shore. All the boats down within the last two weeks have grounded here, and lain from 6 to 48 hours. The day has been quite windy, and we were several times driven ashore. We passed the Centralia above Hamilton ranch, waiting on the wind.

September 10.—Started 7 a. m., and at 8 a. m. ran aground opposite Tower butte. The morning is clear and cold, with but little wind; cleared the bar at noon, and at 2 p. m. reached Yancton agency, the wind in the meantime having suddenly revived and driven us once ashore. Since leaving Fort Rice I have noticed a peculiarity in the bar formation, but seldom observed above. Sand bars and sand-islands form in the middle of the stream, giving a series of middle bars and doubtful crossings, the channel shifting frequently from one side to the other, and giving a difference in depth on either side so small as to often deceive the most practiced pilots.

Above Rice these middle bars are the exception, the bars forming below each point, and running obliquely towards the next lower, permitting but a single crossing, and that generally well defined. Left Yancton agency 5.30 p. m., and lay for the night above the mouth of the Niobrara.

September 11.—Started at daylight, and lay up for the night at the mouth of Vermillion river. Found the channel much obstructed by snags, those most in the way being of recent deposit. In the bend below Yancton village boats have been obliged to cut a channel through a cluster of very large green trees deposited within the last six weeks; the snags vary in diameter from 6 to 18 inches, and the most troublesome come from this season's cutting.

The mouth of Vermillion river is dammed up for a distance of 200 yards by a deposit of mud and sand from the Missouri. Over this dis-

tance the Vermillion falls 5½ feet, with a rapid current; the water-way is ten feet wide and from one to two feet deep—the water clear and cold. All the small streams below the Yellowstone have been dammed in a similar manner, but have cut out, so far as observed. Above the dam the Vermillion is about 50 yards wide, and with a sluggish current.

September 12.—Started at daylight with a better river than yesterday, but still much obstructed by snags. Morning cloudy with a little wind; reached Sioux City 2 p. m., and remained until 3 p. m. Lay up for the night 15 miles below. In the first bend below Sioux City, made a square crossing, and at its terminus found the channel contracted to about 100 feet, very deep, and so full of snags that we were half an hour in working our way through them. The bank was from 10 to 15 feet high, and falling in rapidly, promising to increase the width of channel and the number of snags. At Sioux City recommenced sketch to connect with starting point of my assistant.

September 13.—Started at daylight, and ran well all day, reaching Omaha shortly after dark. The river very tortuous, and the bends full of snags. The section from Sioux City to Omaha is considered the most dangerous part of the Missouri, and when once cleared will require constant attention to keep it free from snags. Winding for the greater part of the distance through low easily cut bottom lands, it is subject to very rapid and radical changes of its bed; each flood sweeps into the channel many hundred acres of timber to form dangerous snags, and frequent cut-offs occur to add further obstruction. At several points to-day the pilots informed me that the whole water-way had shifted within the last two months from 300 to 400 yards into timbered points, leaving the last year's channel a barren sand bottom. On the night of the 8th of July a cut-off occurred above Peru, completely changing the channel for 15 miles on either side; several boats were carried through on the 9th, and barely escaped being wrecked. Another, shortly afterward, less fortunate, struck a log and was lost, together with several of her crew.

September 14.—Started at 11 a. m., and at 1 p. m. were driven ashore by the wind at St. Mary's cut off, and were obliged to lie by the remainder of the day. Boats have had trouble just above and in bend below us, even the packet getting aground, yet the river is considered at a good boating stage, and the river trade is quite brisk. Toward night the wind increased in violence, and the clouds of sand from the old bed of the river and from the point below us were almost blinding.

September 15.—Wind very strong all day, and we have not moved from our landing. Every portion of the cabin and state-rooms, coated with sand. Three boats passed us bound up; two of them side-wheel steamers, and the third a stern-wheeler. The side-wheel boats passed the bar above, and the stern-wheel was driven aground by the wind. Direction of wind from south to north.

September 16.—Wind at times increasing to a hurricane, and continuing from the south, with indications of a storm coming up from the northwest. The side-wheel packet Cornelia passed us down late in the afternoon, and the Sunset ditto after dark, tying up one mile below. Lay by all day, and have fair hopes of being able to push ahead to-morrow, as these blows generally last but three days.

September 17.—The wind having moderated during the night, we started down at 6 a. m., and made a run of about 70 miles, when the wind increased to such violence as to drive us to the bank at Nemaha, 1 p. m. A pelting rain accompanied the wind, and forced me to put my sketch aside and depend on my notes of obstructions. The wind abating in a

few hours we again started down, and lay up for the night 20 miles below Nemaha. Passed the Cornelia at Brownsville, the St. Joseph and Sunset at Plattsmouth, and the Underwriter, of Cincinnati, at the wreck of the H. S. Turner, employed in raising it. With our light draught we have been able to run well, but boats drawing from three to three and a half feet experience great trouble in several of the crossings. Dangerous snags are of frequent occurrence, and all the bends are more or less obstructed.

September 18.—River fair all day. Reached St. Joseph's 5.30 p. m., and remained until next morning. The crossing above St. Joseph's, which three days ago gave great trouble and necessitated sparring on three feet of water, is now cut out, and at no place has less than five feet over the bar. Snags have not been so frequent as yesterday. Day fair and warm.

September 19.—After a run of 175 miles lay up for night at a wood-yard below Liberty. Night clear and cool. As wood is quite an item in the economy of a steamboat, I have collected the following tariff of prices:

At Fort Hawley $8 per cord; Fort Rice $8; Fort Randall and above from $6 to $8; above Sioux City $5; above Omaha $2 50 to $3 50; from Omaha down $2 to $3. The Miner burns in 24 hours 24 cords of hard wood or 30 cords of dry cottonwood. A portion of the river passed to-day is in very good condition, and other portions shallow and snaggy. Almost every bend has its wreck to attest the danger of navigation. Many of them are rotten with age, but others are of recent date, and have become dangerous obstructions. The current is slowly eating into the upper bight of each bend, removing the flood deposit, and daily disclosing new snags. It is a peculiarity of the Missouri, due to its wide flood-bed and low bottom-lands, that when at flood-height the channel is cut across the sand points, making the bight of the bend low down and filling in above. As the water falls the channel gradually works out from the point; the bight is made further and further up; shallow bars form, cut away and reform with wonderful rapidity and uncertainty; and when the river attains its medium stage the channel has passed over the greater part of the bed in the upper half of the bend, and brought in succession each snag in that portion directly in the way of navigation.

September 20.—Ran to Slaughter-house island, just above Lexington, and tied up for the night. During the day have passed alternating sections of good and bad river, reported in detail in my snag records. Above Glasgow one very bad bend obstructed by bars, and also a similar series of bends and crossings above and below Slaughter-house island. From Glasgow to the latter section the channel is remarkably good. The day has been warm and pleasant.

September 21.—Were detained at our moorings until 8 a. m. by a fog; we then ran until dusk, and tied up half a mile above Pinkney. Found the channel much obstructed by bars and snags. Loaded boats have had great difficulty at several points passed during the day. As we draw but two feet, we have had no trouble. The fog this morning, though not heavy, clung to the water and obscured the view at a distance ahead, so that the pilots could not judge of the terminus of the Pinkney and Miller's landing crossing, and be sure of taking the proper channel.

September 22.—Again detained by a fog until 8 a. m., when we started from Slaughter-house island, and at 1.30 p. m. made St. Charles without trouble, although we passed several very bad bends full of snags. Made St. Louis 5.30 p. m. The river from St. Charles to St. Louis very good, with the exception of the Chobenier islands section, where the channel is

liable to frequent shiftings from one side of the island to the other. The importance of clearing the river of snags from its mouth to Omaha is in a great measure due to the packet-trade on that section, which necessitates running at night, and makes obstructions of the kind so much the more dangerous.

September 23, 24.—Remained in St. Louis collecting commercial statistics from the quartermasters' and commissary departments, and from the records of the Union Merchants' Exchange.

September 26.—Three p. m. started for Cincinnati via Ohio and Mississippi railroad.

September 27.—Arrived in Cincinnati 5 a. m.

Itinerary of route.

Date.	Place of departure.	Time of—		Delay.	
		Starting.	Stopping.	Time.	Cause.
1867.				*Hours.*	
July 12	Sioux City	10.30 a. m	12 p. m	3	Wooding at Brazeans.
13	Ponka	3 a. m	10 p. m	1	Wooding.
14	Bow river	3 a. m	12 p. m	1	Wooding.
15	Ponka agency	4 a. m	7 a. m		
	Yancton agency	8 a. m	12 m	3	In port.
16	Fort Randall	2 p. m	8 p. m		
16	Hamilton Ranch	3 a. m	9 p. m	2	Cutting wood.
17	Byon hills	4 a. m	9 p. m		
18	St. John's wood-yard	4 a. m	1 p. m	8	Wooding at Old Fort Sully.
19	Old Fort Sully	4 a. m	12 m	9	Discharging freight, &c.
20	New Fort Sully	12 m	9 p. m	8	Discharging freight, &c.
21	Below Big Shayenne	4 a. m	6 p. m	3	Wooding at foot of Swan lake reach.
22	Fort Swan Lake Reach	5 a. m	6 p. m	3	Wooded below Fox island.
23	Below Fox island	4 a. m	6 p. m	3	Wooded at Bombeuse creek.
24	Bombeuse creek	4 a. m	6 p. m	3	Wooded below Battle creek.
25	Below Battle	4 a. m	4 p. m	5	Discharging freight.
26	Fort Rice	3.30 a. m	1 p. m	3	Wooding 40 miles above Rice.
26	Forty miles above Rice	4 p. m	6 p. m	4	By storm and damage to boat, &c.
27	Forty-five miles above Rice.	7 a. m	9 a. m	15	Repairing damage, wooding, and wind.
28	Sixty miles above Rice	4 a. m	7 p. m	2	Wooding at Square Buttes.
29	Square buttes	3.30 a. m	6 p. m	3	Discharging freight at Stevenson's.
30	Fort Stevenson's	3.30 a. m	9 a. m	15	Discharging freight at Berthold.
31	Fort Berthold	3.30 a. m	9 p. m		Sand-bar in Great Bend.
August 1	Sand-bar Great Bend	3.30 a. m	9 p. m	2	Stopping several times for wood.
2	At White Earth river	4 a. m	3 p. m	6	Wind storm.
3	Below Muddy river	3.30 a. m	5.40 p. m	3	Discharging freight at Buford.
4	Fort Buford	8.30 a. m	11.30 a. m	4	Discharging freight at Buford.
4	Fort Union	1.30 p. m	8 p. m	2	Stoppage at Fort Union.
5	Below Stone Point	4 a. m	8 p. m	4	Difficult bars near Fort Kip.
6	Above Poplar river	6.30 a. m	4 p. m	12	Six hours' sparring, six hours' wooding.
7	Second bend above	4 a. m	7 p. m	6.30	Four and one-half hours on bars, two wooding.
8	Near Porcupine creek	4 a. m	8 a. m		Reached Milk river.
	Milk river	8 a. m	7 p. m		Fifteen miles in 11 hours.
9	Dry Fork	4 a. m	9 p. m	2	On bar four hours for wood.
10		4 a. m	8.30 p. m		Slow past Round Buttes.
11	Point au Poche	4 a. m	9 p. m	1	In false channel.
12	Fort Hawley	4.30 a. m	8 p. m	4	To speak steamer Guidon and to wood.
13	Two-calf island	4.30 a. m	5 p. m	7.30	Rapids and bars.
14	Cow island	6 a. m	3 p. m		Nine hours passing rapids.
15	Benton road	7 a. m	7 p. m	2	By storm two and one-half miles below Dauphin's.
16	Two and one-half miles below Dauphin's.	5 a. m	8 a. m		One and one-half mile in three hours.
	Dauphin's	7 p. m	8 p. m		
17	Three miles below Dauphin's.	4 a. m	7 a. m	3	At Snake Point.
	Snake Point	12 m	1 p. m	7	Below Snake Point on bar.
18	On bar	10 a. m	1 p. m	6	Below Snake Point on bar.
20	Benton road	7 a. m	10 a. m	7	Grand island bar.
	Grand island bar	5 p. m	8 p. m		
21		4 a. m	9.30 a. m		
	Fort Hawley	12 m	4.30 p. m	2.30	At Fort Hawley.
22	Wood-pile	4 a. m	12 m	8	Lay from 12 m. until morning on bar.

Itinerary of route—Continued.

Date.	Place of departure.	Time of—		Delay.	
		Starting.	Stopping.	Time.	Cause.
1867.				*Hours.*	
Aug. 23	Round Butte bar	7 a. m.	7 a. m.	13	All day at bar opposite Butte.
24	Bar opposite Butte	4 a. m.	6 p. m.	2	Sounding below Milk river.
25	Two miles below Milk river.	5 a. m.	4. 30 p. m.	7	Two hours' sparring and two wooding.
26	Fort Charles	5 a. m.	4. 30 p. m.	3	Wind.
27		5 a. m.	6. 30 p. m.		Delayed by wind.
28	Fort Buford	8 a. m.	9 p. m.	6. 30	By wind.
29	Below Muddy river	4 a. m.	8 p. m.	3	Bars and wooding.
30	Lidi creek	4 a. m.	12 m	6	At Berthold.
	Fort Berthold	6 p. m.	7 p. m.	1	Tied up for wind.
31	Below Fort Berthold	4 a. m.	8. 30 a. m.	23	At Stevenson's.
	Fort Stevenson	11 a. m.	4 p. m.	4	Wooding.
Sept. 1	Below Big Knife river	5 a. m.	3. 30 p. m.	2. 30	At Fort Rice.
	Fort Rice	6 p. m.	7 p. m.	1	Wooded below Cannon Ball.
2	Below Cannon Ball	5 a. m.	4 p. m.	3	By wind.
3	Above Grand river	5 a. m.	7 p. m.	1	Taking false channel.
4	Above Big Shayenne	5 a. m.	9 a. m.		Thirty miles in 17 hours: cause, bars.
	Big Shyenne	9 a. m.	12 m		
	Below Fort Sully	12 m	2 p. m.	2	At New Fort Sully.
	Anquer Bongar island	2 p. m.	7 p. m.		Wooded and tied up for night.
5	Old Fort Sully	5 a. m.	7 p. m.	6	By bars passing Old Sully.
6	Below Old Fort Sully				Made 15 miles during the day; cause wind.
7	Below Old Fort Sully	6 p. m.	7 p. m.	13	Made five miles, wind.
8	Below Old Fort Sully	5 a. m.	9 a. m.	7	Wind.
	Above Fort Thompson	4 p. m.	9 p. m.		Wooded during night.
9	Opposite Corn creek	5 a. m.	5. 30 p. m.	1	Stopping at Randall.
	Fort Randall	6. 30 p. m.	7 p. m.		Aground on bar opposite Randall.
10	Opposite Fort Randall	7 a. m.	8 a. m.	6	Four hours on bar at Lower Butte and two Randall bar.
	Lower butte	12 m	2 p. m.	3. 30	Yancton agency, wind.
	Yancton agency	5. 30 p. m.	8 p. m.		
11	Niobrara	5 a. m.	8 p. m.		Vermillion during night.
12	Vermillion	6 a. m.	2 p. m.	1	At Sioux City.
	Sioux City	3 p. m.	7 p. m.	½	By snags in bend.
13	Below Sioux City	5 a. m.	8 p. m.		
14	Omaha	11 a. m.	1 p. m.		Six hours at Omaha and six for wind at St. Mary's.
15	St. Mary's	11 a. m.		14	All day for wind.
16	St. Mary's	11 a. m.		14	All day for wind.
17	St. Mary's	6 a. m.	1 p. m.	3	At Nemaha.
	Nemaha	4 p. m.	7 p. m.		
18	Below Nemaha	5 a. m.	5. 30 p. m.		Over night at St. Joseph.
19	St. Joseph	5 a. m.	7 p. m.		Night at wood-yard below Liberty.
20	Below Liberty	5 a. m.	7 p. m.		Night at Slaughter-house island.
21	Slaughter-house island	8 a. m.	8 p. m.	3	By foggy morning.
22	Piukney	8 a. m.	8. 30 p. m.		
	St. Charles	10. 30 p. m.	5. 30 p. m.		Arrived at St. Louis.

Partial list of snags and wrecks in the lower section of the Missouri river, beginning at Fort Randall, D. T.

Place.	Shore.	No.	Remarks.
Fort Randall—			
To Tower butte	Left	6	
To Yancton agency		20	
To Niobrara	Right	13	
To bend below Niobrara	Left	5	
To bend above Bonhomme	Right	8	Cutting into timber.
To Yancton	Right	15	Timbered along Bonhomme island.
To 1st bend below Yancton	Left	25	Snag cluster troublesome, cutting into timber.
To Dakota river	Left	11	Cutting on left into timber.
To Bow river	Left	19	Cutting on left into timber.
To Tide creek	Left	30	Cutting on left into timber.
To Vermillion	Right	6	Cutting into timber.
To Vermillion Bend	Left	13	Cutting into timber.
To 1st bend below	Right	4	

Partial list of snags and wrecks, &c.—Continued.

Place.	Shore.	No.	Remarks.
bend below	Left	15	Cutting timbered bank.
er Fork Bend	Right	3	
t bend below	Left	21	Cutting timbered bank.
nka		10	
t bend below Ponka	Right	6	
bend below Ponka	Left	15	Cutting timbered bank.
bend below Ponka	Right	8	Cutting timbered bank.
h bend below Ponka	Left	5	Cutting timbered bank.
h bend below Ponka	Right	12	Cutting timbered bank.
oux City cut-off	Right	18	
oux City	Left	3	
r Floyd river	Right	5	Cluster.
ad Willow bar	Right	8	Cluster.
ot Willow bar	Right	6	Cluster.
ad of 1st bend	Right	15	Cluster in narrow channel very troublesome.
bend	Channel	6	Channel unnatural and shifting.
l bend	Right	7	Cutting timbered banks.
h bend	Right	9	Blackbird hills cutting timbered banks.
h bend	Left	10	Cutting into timber.
h bend	Right	5	Cutting to timber on left.
h bend	Left	3	Cutting to timber on left.
h bend	Right	12	Cutting to timber on left.
th bend	Left	0	Cutting into prairie.
th bend	Right	9	In upper part of bend timbered.
th bend	Left	21	Close cluster across channel. Sunken steam'r.
th bend	Right	6	Upper half of bend.
th bend	Left	25	Close cluster across channel. Mariner sunk.
th bend	Right	0	Cutting into prairie.
e Little Sioux river	Left	10	Cutting into timber.
e Little Sioux river	Right	15	Cutting into timber.
r Little Sioux river	Left	13	Cutting into timber.
r 1st bend	Right	12	Cutting into timber.
r 2d bend	Left	10	
r 3d bend	Right	9	Cutting into prairie and willows.
r 4th bend	Left	23	Cutting into timber, bad place.
above cut-off	Right	2	Cutting into willows.
ff	Left	9	Cutting into willows and timber.
r cut-off	Left	10	Will be entirely changed next year.
above Desoto	Left	10	Cutting into timber very rapidly 600 feet in two months.
a Bend	Right	2	
below Desoto	Right	10	Cutting into timber. Cluster.
Calhoun	Right	1	Cutting into timber.
lorence		0	
below Florence	Left	4	
above Omaha	Right	0	
bend below	Left	3	
d bend below	Right	0	
l bend below	Left	8	
Mary's cut-off		12	
r St. Mary's cut-off	Right	7	
Plattsmouth		16	
Hillsboro' landing		5	
Point wood-yard	Left	4	
ston landing	Left	8	
ille landing	Left	3	
e Jane's Point	Right	2	
r Jane's Point	Right	4	
below Janes's cross-	Right	30	Ought to be removed.
e Wyoming	Right	40	Great number large.
r Wyoming	Left	10	
bend below	Right	30	H. S. Turner sunk by one.
above Nebraska city	Left	23	Mostly large.

Partial list of snags and wrecks, &c.—Continued.

Place.	Shore.	No.	Remarks.
First below Nebraska city		30	Channel cutting into wood.
First Sydney landing		6	
Above cut-off	Right	5	
Above Kansas Bend	Left	30	
Cut-off above Peru		6	
Peru Bend		2	One head bar. One above. Tow head.
Brownsville		6	
Nemaha Bend		6	Number in bank.
Opposite month of Nemaha		16	
Below month of Nemaha			Three breaks.
Below St. Stephen's	Left	5	
Above Rulo		4	Timbered bank.
Rulo Bend		20	Old mouth of Nemaha.
Big Parkie		10	
Below Big Parkie		12	Across river.
Bend below Nemaha	Left	20	Chain between bar and Sand point.
Forcest City landing		25	Timbered banks.
Iowa Point		8	
Below Iowa Point		3	
At Lafayette	Left	11	
Crossing below Lafayette bend	Left	10	
Charleston Bend	Right	7	
Arizona Bend	Right	13	
Arizona Bend	Left	8	
Arizona Bend	Right	6	No timber.
Next Bend	Right	9	Timbered.
Above St. Joseph	Left	15	No timber.
Above St. Joseph	Right	15	
St. Joseph		20	
To Alan's		27	Little timber.
Alan's Bend	Right	2	
Below St. Joseph	Left	17	
Below Alan's	Right	6	
Below St. Joseph	Left	30	Smith's bend.
Dauphano Bend		6	
Dauphano Bend	Left	24	Partly timbered.
Below Atchison	Left	7	
Bend below Atchison		6	Cutting into timber.
Second bend below Atchison	Left	3	
Kickapoo		5	
Weston		10	
Fort Leavenworth	Right	16	
Above Parkville	Right	18	
Quindaro	Right	10	
Above Wyandotte	Left	16	
Wyandotte Bend	Right	3	Cut away 100 yards in last four months
Kansas City	Left	6	
Kansas City below	Right	14	
Kansas City below	Left	13	
Wayne City	Left	6	
Wayne City crossing		5	
Below Liberty landing	Left	10	
Below Liberty landing	Left	24	
Above Missouri City	Right	8	
Below Missouri City	Left	11	
Below Missouri City	Right	16	
Below Missouri City	Left	15	
Liberty Bend	Right	10	
Napoleon	Right	5	
Below Napoleon	Left	20	Bend full of breaks.
Below Camden	Right	15	
Below Camden	Left	1	
Wellington	Right	12	

Partial list of snags and wrecks, &c.—Continued.

Place.	Shore.	No.	Remarks.
e Bend	Right	10	Timber.
e Bend	Right	20	
e Bend	Right	8	
t Cambridge	Left	30	
dge Bend	Right	17	
sland	Left	10	Wreck—Snagged.
sland	Left	15	
City Bend	Right	11	Little Arrow Rock.
	Left	8	
Rock	Right	10	Channel full of snags.
n Bend island	Left	40	
n Bend island	Right	1	
Point	Left	11	
Bend	Right	13	
rt bluff	Left	2	
n island		1	
e Mount Vernon	Left	17	
boy Bend	Right	8	
nce Bend	Right	6	
Shore Bend	Right	11	
nce Bend	Left	6	
Hook	Right	30	
Sandy Hook		5	
	Right	5	
Bend island		8	
le	Right	20	
n City Bend	Left	3	
e Jefferson city	Left	3	
n City Bend	Right	4	
n City, opposite l	Left	13	
n City, opposite l	Right	10	
Osage chute	Right	10	
ert island			Wreck of Robert Emmett.
and	Left	25	Wreck of Mollie Dozier in channel.
d Bend	Left	1	Wreck of Sonora and Lancaster.
fftown	Right	26	
ade island, of Gasconade river	Right	18	Worse place in lower river—channel shifts from right to left of island.
Gurk's island		9	
Herman	Right	1	
sland	Left	25	Rock heap.
Brush island			Large cluster across channel.
bove Pinkney		15	
elow Pinkney	Left	18	
Miller's landing	Right	10	
Bend		4	
n's landing	Left	3	
Pohlman's landing	Right	4	
t. John's island		35	Full of snags and rock heaps.
Washington City	Left	40	Opposite St. John island.
Augusta	Right	15	
a Bend	Right		Snaggy and shifting wrecks of Parker and Eaton.
k's Point	Right	7	Rock heaps.
k's Point	Right	7	
Pow Head	Left	12	
n Coal Bank	Right	15	
ton	Left	3	
ton	Right	8	
ton island	Right	19	
Shanghai	Left	18	
Shanghai	Left	14	

Partial list of snags and wrecks, &c.—Continued.

Place.	Shore.	No.	Remarks.
Above Waverly	Right	1	
Below Waverly	Right	7	
Opposite Crane	Right	5	
Below Crane	Left	8	
Malta Bend	Right	13	
Below Malta Bend	Left	15	
Below Malta Bend	Right	20	
Kietsaw	Left	19	
Miami, above	Right	24	Timbered bank.
Miami, above	Right	3	Timbered bank.
Magenta Bend	Left	30	Magenta, sunk 1863.
Brunswick	Right	9	
Brunswick, above Grand river		40	
Below Brunswick	Right	52	
Below Brunswick	Left	1	
Buckhorn Point	Right	8	
Along Bend	Right	17	
Bowling Green	Left	30	Heavy timber.
White Hall landing		9	
Moinage Bend	Right	15	
Port Royal			Shaft of steamer Amaranth.
Dozier	Left	13	Cutting fast.
Dozier crossing		4	
Below Bonhomme island		2	
Howard's Bend		15	
Howard's Bend	Right	15	
Point St. Charles island		8	
St. Charles	Right	12	
St. Charles Bend		13	
Chabonier island		8	Right chute.
Chabonier island		10	Left chute.
To Corcomas Point		2	
Peluvin island	Right	12	
Brickhouse Bend			Said to be bad.
Bellfontain bluff		3	
Green island	Left	9	
Green island	Right	25	

GAUGE RECORDS.

Stage of the Missouri river from the 12th July, 1867, to the 22d September, 1867, from partial records kept during the second trip of the steamer Miner from Sioux City and return to St. Louis, Missouri.

From—	To—	Hours observed.	Rise.	Fall.	Estimate change to next station.		
					Running hours.	Rise.	Fall.
1867.			*Feet.*	*Feet.*		*Feet.*	*Feet.*
July 12, 12 p. m	July 13, 3 a. m	3	.04		19	.25	
July 13, 10 p. m	July 14, 3 a. m	5		.05	21		.21
July 14, 12 p. m	July 15, 4 a. m	4		.04	16		.16
July 15, 8 p. m	July 16, 3 a. m	7		.07	18		.18
July 16, 9 p. m	July 17, 4 a. m	7		.08	17		.20
July 17, 9 p. m	July 18, 4 a. m	7		.08	9		.10
July 18, 1 p. m	July 19, 4 a. m	15		.16	8		.08
July 19, 12 m	July 25, 12 m	24		.25	9		.08
July 20, 9 p. m	July 21, 4 a. m	7		.06	14		.12
July 21, 6 p. m	July 22, 5 a. m	11		.09	13		.10
July 22, 6 p. m	July 23, 4 a. m	10		.09	14		.12
July 23, 6 p. m	July 24, 4 a. m	10		.08	14		.11

Stage of the Missouri river from the 12th of July, 1857, &c.—Continued.

m—	To—	Hours observed.	Rise.	Fall.	Estimate change to next station.		
					Running hours.	Rise.	Fall.
57.			*Feet.*	*Feet.*		*Feet.*	*Feet.*
p. m	July 25, 4 a. m.....	10	.....	.08	12	.....	.10
p. m	July 26, 3.30 a. m ..	11½	.....	.07	14½	.....	.08
p. m	July 27, 7 a. m.....	13	.04	.....	2	.01	.....
p. m	July 28, 4 a. m.....	19	.06	.....	15	.05	.....
p. m	July 29, 3.30 a. m..	8½	.06	.....	14½	.12	.....
p. m	July 30, 3.30 a. m..	9½	.....	.02	17½	.....	.04
a. m.....	July 31, 3.30 a. m..	18½	.....	.06	17½	.....	.07
p. m.....	Aug. 1, 3.30 a. m..	6½	.....	.02	17½	.....	.09
p. m.....	Aug. 2, 4 a. m.....	7	.....	.03	11	.....	.05
p. m.....	Aug. 3, 3.30 a. m..	12½	.....	.06	14	.....	.08
40 p. m..	Aug. 4, 8.30 a. m..	15	.....	.07	11	.....	.06
p. m.....	Aug. 5, 4 a. m.....	8	.....	.04	16	.....	.08
p. m.....	Aug. 6, 6.30 a. m..	11½	.....	.05	9½	.....	.04
p. m.....	Aug. 7, 4 a. m.....	12	.....	.05	15	.....	.06
p. m.....	Aug. 8, 4 a. m.....	9	.....	.04	15	.....	.06
p. m.....	Aug. 9, 4 a. m.....	9	.....	.04	17	.....	.08
p. m.....	Aug. 10, 4 a. m.....	7	.....	.03	16½	.....	.07
30 p. m..	Aug. 11, 4 a. m.....	7½	.....	.03	17	.....	.07
p. m.....	Aug. 12, 4.30 a. m..	7½	.....	.03	15½	.....	.07
p. m.....	Aug. 13, 4.30 a. m..	8½	.....	.04	12½	.....	.06
p. m.....	Aug. 14, 6 a. m.....	13	.....	.08	9	.....	.06
p. m.....	Aug. 15, 7 a. m.....	16	.....	.10	12	.....	.08
p. m.....	Aug. 16, 5 a. m.....	10	.....	.08	3	.....	.02
p. m.. ..	Aug. 16, 7 p. m.....	11	.....	.09	1	.....	.01
p. m.....	Aug. 17, 4 a. m.....	8	.....	.06	3	.....	.02
a. m.....	Aug. 17, 12 m.....	5	.....	.04	1	.....	.01
p. m.....	Aug. 18, 10 a. m....	21	.....	.20	3	.....	.03
p. m.....	Aug. 20, 7 a. m.....	42	.....	.35	13	.....	.12
p. m.....	Aug. 21, 4 a. m.....	8	.....	.05	12½	.....	.07
30 p. m ..	Aug. 22, 4 a. m.....	11½	.....	.05	8	.....	.03
2 m	Aug. 23, 4 a. m.....	16	.....	.04	3	.....	.01
a. m.....	Aug. 24, 4 a. m.....	21	.....	.06	14	.....	.04
p. m.....	Aug. 25, 5 a. m.....	11	.....	.03	11½	.....	.03
30 p. m..	Aug. 26, 5 a. m.....	12½	.....	.03	11½	.....	.03
30 a. m..	Aug. 27, 5 a. m.....	12½	.....	.04	13½	.....	.04
30 a. m..	Aug. 28, 8 a. m.....	13½	.....	.06	13	.....	.07
a. m.....	Aug. 29, 4 a. m.....	7	.....	.03	12	.....	.05
p. m.....	Aug. 30, 4 a. m.....	8	.....	.03	8	.....	.03
2 p. m....	Aug. 31, 4 a. m.....	16	.....	.05	12	.....	.04
p. m.....	Sept. 1, 5 a. m.....	13	.....	.04	14	.....	.04
p. m.....	Sept. 2, 5 a. m.....	10	.....	.03	11	.....	.03
p. m.....	Sept. 3, 5 a. m.....	13	.....	.05	14	.....	.06
p. m.....	Sept. 4, 5 a. m.....	10	.....	.04	14	.....	.05
p. m.....	Sept. 5, 5 a. m.....	10	.....	.03	14	.....	.04
p. m.....	Sept. 6, 9 a. m.....	14	.....	.08	10	.....	.08
p. m.....	Sept. 8, 5 a. m.....	10	.....	.07	4	.....	.03
a. m.....	Sept. 8, 4 p. m.....	7	.....	.05	5	.....	.04
p. m.....	Sept. 9, 5 a. m.....	8	.....	.05	14	.....	.07
p. m.....	Sept. 10, 7 a. m.....	12	.....	.01	13	.....	.12
p. m.....	Sept. 11, 5 a. m.....	9	.....	.10	15	.....	.18
p. m.....	Sept. 12, 6 a. m.....	10	.....	.11	13	.....	.12
p. m.....	Sept. 13, 5 a. m.....	10	.....	.08	15	.....	.11
p. m.....	Sept. 14, 11 a. m....	15	.....	.10	2	.....	.02
p. m.....	Sept 15, 6 a. m.....	17	.....	.15	.....	.....	.....
a. m.....	Sept. 16, 6 a. m.....	24	.....	.26	.....	.....	.....
a. m.....	Sept. 17, 6 a. m.....	24	.....	.22	13	.....	.12
p. m.....	Sept. 18, 5 a. m.....	10	.....	.08	12½	.....	.10
30 p. m..	Sept. 19, 5 a. m.....	11½	.....	.10	14	.....	.12
p. m.....	Sept. 20, 5 a. m.....	10	.....	.08	14	.....	.11
p. m.....	Sept. 21, 8 a. m.....	13	.....	.08	12	.....	.07
p. m.....	Sept. 22, 8 a. m.....	12	.....	.08	9½	.....	.06
30 p. m..	Sept. 23, 5 a. m.....	11½	.....	.08	.....	.....	.....

TIME OF TRIP.

	Hours.
St. Louis to Sioux City.....	212
Sioux City to Dauphin's rapids and return to St. Louis....	1,698
Total round trip.....	1,910

RUNNING TIME.

	Hours.
From Sioux City to Dauphin's and return to St. Louis	850
Delays from Sioux City to Dauphin's and return to St. Louis	848

FALL OF RIVER.

	Feet.
From 12th of July to 23d of September, record of trip	9.73
From 12th of July to 23d of September, St. Louis record	18.48
From 14th of August to 31st of August, record of trip	1.60
From 14th of August to 31st of August, Fort Rice record	2.54
From 14th of August to 31st of August, St. Louis record	4.39
From 1st of July to 30th of September	16.27

Rise and fall of the Missouri river at Fort Rice, D. T., from August 14, 1867, to August 31, 1867; recorded by First Lieutenant W. I. Reedy, 22d infantry, and acting assistant quartermaster.

Date.	Time.	Rise.	Fall.
1867.			
August 14	Night		.08
15	Night		.12
16	Day		.08
16	Night		.12
17	Day		.12
17	Night		.12
18	Day	.08	.00
18	Night		.06
19	Day		.06
20	Night		.08
21	Day		.00
21	Night		.12
22	Day		.00
22	Night		.00
23	Day		.12
23	Night		.12
24	Day		.08
24	Night		.08
25	Day		.16
25	Night		.16
26	Day		.08
26	Night		.12
27	Day		.08
27	Night		.08
28	Day and night		.17
29	Day and night		1.09
30	Day and night		.16
31	Day and night		.00

Stage of the Mississippi river at St. Louis, Missouri, during the months of July, August, and September, 1867; from the official records of the engineer of the city of St. Louis.

Date.		Above low water of 1863.	Below high water of 1844.	Below city directrix.	Rise.	Fall.
1867.		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
July	1	24.52	16.87	9.29	0.48	.....
	2	24.64	16.75	9.17	.12	.....
	3	24.72	16.66	9.08	.09	.....
	4	.....	.....	.....	.....	.....
	5	25.42	15.97	8.39	.69	.....
	6	25.89	15.50	7.92	.47	.....
	7	.....	.....	.....	.....	.....
	8	26.39	15.00	7.42	.50	.....
	9	26.81	14.58	7.00	.42	.....
	10	26.71	14.64	7.10	.....	0.10
	11	26.75	14.64	7.06	.04	.....
	12	26.29	15.10	7.52	.....	0.46
	13	26.25	15.14	7.56	.....	.04
	14	.....	.....	.....	.....	.....
	15	25.93	15.46	7.88	.....	.32
	16	25.89	15.50	7.92	.....	.04
	17	26.39	15.00	7.42	.50	.....
	18	26.66	14.73	7.15	.27	.....
	19	26.27	15.12	7.54	.....	.39
	20	25.31	16.08	8.50	.....	.96
	21	.....	.....	.....	.....	.....
	22	24.31	17.08	9.50	.....	1.00
	23	23.64	17.75	10.17	.....	.67
	24	23.14	18.25	10.67	.....	.50
	25	22.48	18.91	11.33	.....	.66
	26	22.21	19.18	11.60	.....	.27
	27	21.02	20.37	12.79	.....	.19
	28	.....	.....	.....	.....	.....
	29	21.10	20.29	12.71	.08	.....
	30	20.21	21.18	13.60	.....	.89
	31	.....	.....	.....	.....	.....
Aug.	1	19.94	21.45	13.87	.....	.27
	2	19.75	21.64	14.06	.....	.19
	3	19.44	21.95	14.37	.....	.31
	4	.....	.....	.....	.....	.....
	5	19.00	22.39	14.81	.....	.44
	6	18.50	22.89	15.31	.....	.50
	7	18.04	23.35	15.77	.....	.46
	8	17.54	28.85	16.27	.....	.50
	9	17.50	23.89	16.31	.....	.04
	10	17.31	24.08	16.50	.....	.19
	11	.....	.....	.....	.....	.....
	12	17.00	24.39	16.81	.....	.31
	13	16.92	24.47	16.89	.....	.08
	14	16.87	24.52	16.94	.....	.05
	15	16.71	24.68	17.10	.....	.16
	16	16.61	24.78	17.20	.....	.10
	17	16.39	25.00	17.42	.....	0.22
	18	.....	.....	.....	.....	.....
	19	15.79	25.60	18.02	.....	.60
	20	15.54	25.85	18.27	.....	.25
	21	15.31	26.08	18.50	.....	.23
	22	14.96	26.43	18.85	.....	.35
	23	14.58	26.81	19.23	.....	.38
	24	14.23	27.16	19.58	.....	.35
	25	.....	.....	.....	.....	.....
	26	13.71	27.68	20.10	.....	.52
	27	13.39	28.00	20.42	.....	.32

Stage of the Mississippi river at St. Louis, Missouri, &c.—Continued.

Date.	Above low water of 1863.	Below high water of 1844.	Below city directrix.	Rise.	Fall.
1867.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Aug. 28	13.25	28.14	20.56	.....	.14
29	13.04	28.35	20.77	.....	.21
30	12.69	28.70	21.12	.....	.35
31	12.48	28.91	21.33	.....	.21
Sept. 1	.....	.....	.....	.....	.....
2	12.44	28.95	21.37	.....	.04
3	12.27	29.12	21.54	.....	.17
4	12.00	29.39	21.81	.....	.27
5	11.67	29.72	22.14	.....	.33
6	11.35	30.04	22.46	.....	.32
7	11.02	30.37	22.79	.....	.33
8	.....	.....	.....	.....	.....
9	10.73	30.66	23.08	.....	.29
10	10.56	30.83	23.25	.....	.17
11	10.33	31.06	23.48	.....	.23
12	10.08	31.31	23.73	.....	.25
13	9.85	31.54	23.96	.....	.23
14	9.56	31.83	24.25	.....	.29
15	.....	.....	.....	.....	.....
16	9.00	32.39	24.81	.....	.56
17	8.77	32.62	25.04	.....	.23
18	8.56	32.83	25.25	.....	.21
19	8.39	33.00	25.42	.....	.17
20	8.23	33.16	25.58	.....	.16
21	8.06	33.33	25.75	.....	.17
22	.....	.....	.....	.....	.....
23	7.81	33.58	26.00	.....	.25
24	7.77	33.62	26.04	.....	.04
25	.....	.....	.....	.....	.....
26	.....	.....	.....	.....	.....
27	7.73	33.66	26.08	.....	.04
28	8.50	32.89	25.31	.77	.....
29	.....	.....	.....	.....	.....
30	8.25	33.14	25.56	.....	.25

COMMERCIAL STATISTICS.

Arrivals and departures of steamers at St. Louis to and from Missouri river.

Arrived.	Number.	Departed.	Number.
January	.....	January	.....
February	2	February	5
March	12	March	29
April	35	April	56
May	28	May	59
June	44	June	31
July	46	July	32
August	40	August	41
September	33	September	33
Total	246	Total	286

ial list of accidents to the Missouri river fleet for the season of 1867.

ner.	Accidents.
Watts..	Struck a heavy log and returned to St. Louis for repairs.
rover..	Grounded at Point-Au-Pocke and proved a total loss; cargo saved.
.....	Sunk near De Soto; boat and cargo lost.
dge...	On second trip broke her shaft near Decatur and returned to St. Louis.
th.....	Broke her shaft at De Soto and returned to St. Louis.
ance..	Met with accident at Little Sioux and returned to St. Louis.
rner..	Sunk by snag below Wyoming.
Poe....	Snagged and sunk at Gasconade island.
rn.....	Wrecked in Peru Cut-off.
[.....	On her return caught by low water at Milk river and will probably be lost. (Arrived at St. Joseph, Missouri, safe.)
r.....	Snagged and sunk in Bowling Green bend November 24, 1867. Total loss.
elle ...	Sunk at Lisbon landing November 26, 1867.
.....	Last reported aground near Milk river.

ent of steamers that left St. Louis for Fort Benton and the upper souri, with the date of arrival at destination, with tons of freight n up and date of return to St. Louis.

Boat.	Left St. Louis.	Arrived at—	Date.	Freight.	Returned.
				Tons.	
Poe.....	March 28	Fort Benton..	June 9	183	June 25
ance.....	March 28	Do	June 1	185	June 16
nson.....	March 29	Do	June 14	265	July 4
rn.....	March 30	Do	June 11	210	June 30
)ance.....	March 30	Do	June 3	198	June 21
r.....	March 31	Do	May 25	160	June 16
lle	March 31	Do	June 14	190	June —
.....	April 1	Do	May 31	150	June 17
neer	April 3	Do	June 10	330	June 25
th.....	April 4	Do	June 30	225	July 18
dge.....	April 6	Do	June 2	208	June 17
... .	April 6	Do	June 3	210	June 16
.....	April 9	Do	July 3	270	.....
's.....	April 10	Do	June 11	129	June 25
.....	April 11	Do	June 20	225	Sept. 5
n	April 12	Do	July 8	218	.....
.....	April 12	Do	June 20	200	July 11
No. 2.....	April 12	Do	.....	150	.....
.....	April 13	Do	June 12	150	June 28
rover.....	April 13	Muscle Shell..	.....	200	Dismantled
.....	April 16	Fort Benton ..	July 4	230	.....
.....	April 18	Do	July 8	242	.....
.....	April 18	Do	.....	150	.....
kdale.....	April 18	Do	June 18	250	.....
.....	April 20	Do	.....	250	.....
Brown	April 20	Do	.....	125	.....
.....	April 20	Fort Buford...	June 12	250	June 25
.....	April 23	Fort Rice.....	June 5	300	June 16
ompson	April 23	Fort Benton ..	June 30	200	July 18
lle.....	April 23	Do	July 23	170	.....
.....	April 24	Do	July 5	180	July 26
.....	April 25	Do	July 8	129	.....
Graham.....	April 26	Fort Buford...	June 26	300	July 8
.....	April 27	Fort Benton ..	July 5	160	July 26

Statement of steamers that left St. Louis for Fort Benton, &c.—Continued.

Boat.	Left St. Louis.	Arrived at—	Date.	Freight.	Returned.
				Tons.	
Ned Tracy	April 27	Fort Berthold	June 21	400	July 1
G. B. Allen	May 1	Fort Rice	June 7	400	June 16
Little Rock	May 1	Fort Benton	July 14	165	
Cornelia	May 3	Fort Berthold	June 13	450	June 24
Lady Grace	May 5	Fort Benton	July 11	234	
Lexington	May 7	Fort Sully	June 20	522	June 30
Silver Lake No. 4	May 7	Fort Benton	July 16	350	
Richmond	May 8	Do	July 27	270	
Tom Stevens	May 11	Do	July 10	100	
Octavia	May 11	Do	June 20	190	July 8
Ida Fulton	May 11	Do	July 16	175	
Nora	May 14	Do	Sunk.		
Imperial	May 17	Cow Island	August 11	225	
Evening Star	May 18	Fort Berthold	June 22	300	June 30
Paragon	May 18	Fort Buford	July 1	400	July 10
Dictator	May 22	Fort Sully	June 16	182	June 26
Zephyr	May 23	Fort Benton		150	
Mary McDonald	May 25	Fort Berthold	June 28	452	July 7
City of Pekin	May 25	Fort Union	July 5	295	
P. S. McGill	May 28	Fort Berthold	July 8	430	
Jennie Lewis	May 31	Fort Sully	June 19	400	June 25
Centralia	June 12	Fort Hawley	August 23	525	Sept. 27
Last Chance	June 18			175	
Miner	June 29	Cow Island	August 13	160	Sept. 22
Carrie	July 2	Fort Buford	August 7	223	
Huntsville	July 3	Fort Benton		250	
Mountaineer	July 3	Fort Berthold	August 7	360	Sept. 16
Only Chance	July 4	Fort Benton	August 29	185	
Deer Lodge	July 29	Fort Buford	August 24	150	
St. John's	August 9	Plum Island	August 29	No freight.	
Mary McDonald	August 10	Fort Berthold	Sept. 3	225	
Benton	August 29			200	
Amaranth	Sept. 3			225	
Lady Grace	Sept. 3	Fort Berthold		225	
Amelia Poe	Sept. 7	Fort Rice		180	
W. B. Dance	Sept. 7			190	
Mountaineer	Sept. 24			300	

Statement of shipments from St. Louis, Missouri, up the Missouri river from January 1 to October 1, 1867.

862 barrels apples.
766 casks bacon.
15,556 packages bacon.
311 sacks bran.
551 packages butter.
5,289 barrels cement.
10,211 sacks coffee.
793 barrels corn meal.
10,098 packages crackers.
20,860 barrels flour.
925 bales gunnies.
2,007 bundles gunnies.
507 bales hay.
8,266 bills, 12,875 pieces.
1,419 packages lard.
607 barrels lime.
1,928 barrels liquor.
7,719 boxes liquor.
1,343 barrels, 1,507 half barrels.
141,627 bushels oats.
263 packages onions.
18,149 bars railroad iron.
7,976 sacks and barrels potatoes.
2,385 coils rope.
1,720 sacks and barrels seed.
164 hogsheads.

Statement of shipments from St. Louis, Missouri, &c.—Continued.

12,184 barrels.
582 boxes.
8,495 M shingles.
2,237 barrels vinegar.
5,170 barrels whisky.
8,761 boxes glass.
3,787 kegs white lead.
1,252 kegs ale and beer.
375 sacks barley.
2,043 sacks and barrels beans.
2,379 bundles brooms.
62 head cattle.
3,292 boxes cheese.
33,155 sacks corn.
51,314 packages cotton yarn.
2,690 sacks and bbls. dried fruit.
129,875 packages groceries.
15,794 packages glassware.
1,852 sacks hair.
45,718 packages hardware.
1,324 tons iron.
1,447 rolls leather.
16,380 feet lumber.
2,068 sacks malt.
31,082 kegs nails.
5,359 kegs molasses.
4,643 barrels oil.
5,710 bundles paper.
1,412 barrels pork.
827 packages pork.
4,964 sacks salt.
33,634 barrels salt.
12,945 bags sugar.
12,001 packages manufactured tobacco.
243 sacks wheat.
267 barrels wine.
3,770 boxes wine.
388,000 packages sundries.

GEO. H. MORGAN,
Secretary Union Merchants' Exchange, St. Louis, Mo.

Statement of receipts at the port of St. Louis from the Missouri river from January 1 to October 1, 1867.

391,734 bushels wheat.
325,060 bushels corn.
94,305 bushels oats.
8,068 bushels rye.
7,460 bushels barley.
2,870 barrels flour.
7,711 hogsheads tobacco.
1,743 boxes tobacco.
21,477 bales hemp and tow.
1,742 packages lard.
674 kegs lard.
3,272 packages furs.
1,379 packages peltries.
2,247 bales and packages wool.
11,694 hides.
829 bundles hides.
215 barrels grease.
2,093 casks and barrels bacon.
10,551 pieces bacon.
1,000 barrels apples.
141 barrels alcohol.
975 sacks bran.
898 sacks dried fruit.
235 barrels pork.
18,318 pieces pork.
508 bales rags.
882 sacks seeds.
354 bales tallow.
133 barrels whisky.
3,522 head cattle.
8,487 head hogs.
2,956 head sheep.
8,986 packages sundries.

GEO. H. MORGAN,
Secretary Union Merchants' Exchange.

List of government freight shipped up the Missouri river by Brevet Lieutenant Colonel C. W. Thomas, quartermaster United States army at St. Louis, Missouri.

Date.	Name of steamer.	Destination.	Pounds weight.	Horses.	Mules.	Ambulances.	Wagons.
March 25	Yellowstone	Fort Leavenworth	189,120	....	....	....	....
29	Sam Gaty	Omaha	353,513	....	....	....	....
30	G. B. Allen	Fort Leavenworth	38,593	....	....	....	....
April 3	Mary McDonald	Omaha	20,018	....	....	....	....
3	H. S. Turner	Fort Leavenworth	4,097	....	....	....	....
4	Mary McDonald	do	200	....	....	....	....
10	War Eagle	Omaha	72,242	....	....	....	....
10	Yellowstone	Fort Leavenworth	32,996	....	....	....	....
11	Jennie Lewis	Omaha	535,344	72	....	....	....
10	St. John's	Fort Sully	2,000	....	....	....	....
10	do	Fort Buford	220	....	....	....	....
10	do	Fort Benton	188,856	....	....	....	2
10	do	Camp Cooke	57,844	....	....	....	....
12	Big Horn	Fort Benton	298,375	....	....	....	2
12	do	Camp Cooke	28,440	....	....	....	....
13	H. S. Turner	do	18,293	....	....	....	4
13	do	Fort Benton	384,873	....	....	....	2
12	Benton	do	20,494	....	....	....	2
12	do	Camp Cooke	297,536	....	....	....	....
10	Jennie Lewis	Omaha	123	....	....	....	....
13	Columbian	do	80,827	....	....	....	....
April 17	Abeona	Fort Benton	.....	....	....	1	....
17	do	Camp Cooke	142,675	....	....	....	6
April 18	Ida Stockdale	Fort Buford	100,000	....	....	....	....
18	G. B. Allen	Fort Leavenworth	22,628	....	....	....	....
18	Lilly	Fort Benton	105,247	....	33	....	2
18	do	Camp Cooke	186,742	....	....	....	....
18	do	Fort Buford	39,569	....	....	....	....
20	W. I. Lewis	Omaha	485,952	....	....	....	....
20	do	Fort Leavenworth	4,440	....	....	....	....
22	Carrie	Fort Buford	434,233	....	....	....	....
20	Gallatin	Camp Cooke	24,085	....	20	....	....
22	G. A. Thompson	do	130,516	....	....	....	10
22	do	Fort Benton	70,338	....	32	3	....
25	Marcella	Fort Randall	212,715	....	....	....	....
25	do	Yucoton	86,899	....	....	....	....
25	do	Omaha	16,900	....	....	....	....
25	Luella	Camp Cooke	99,127	....	....	....	....
25	do	Fort Buford	35,838	....	....	....	....
20	Lilly	Fort Benton	48,510	....	....	....	....
25	Silver Lake, No. 4	Camp Cooke	82,100	....	....	....	....
26	G. W. Graham	Fort Sully	540,047	....	....	....	....
27	Ned Tracy	Fort Rice	241,642	....	....	....	....
27	do	Fort Berthold	410,200	....	78	....	13
27	Yellowstone	Fort Leavenworth	124,648	....	....	....	....
27	Kate Kinney	Omaha	81,963	....	....	....	....
May 1	G. B. Allen	Fort Rice	750,368	....	....	....	....
3	Glasgow	Fort Leavenworth	3,246	....	....	....	....
4	War Eagle	do	64,000	....	....	....	....
3	Cornelia	Fort Berthold	670,190	....	....	....	....
4	Lady Grace	Fort Buford	161,666	....	....	....	....
6	War Eagle	Omaha	372,976	....	....	....	....
7	Sam Gaty	Fort Leavenworth	72,500	....	....	....	....
7	Lexington	Fort Sully	616,899	....	....	....	....
7	do	Fort Randall	64,249	....	....	....	....
7	do	Yancton	361,617	....	....	....	....
7	Silver Lake, No. 4	Camp Cooke	324,037	....	....	....	....

ist of government freight shipped up the Missouri river, &c.—Continued.

Date.		Name of steamer.	Destination.	Pounds weight.	Horses.	Mules.	Ambulances.	Wagons.
May	7	Silver Lake, No. 4..	Fort Buford.....	29,880	....	....	....	....
	4	Lady Grace.....	Fort Benton	155,109	....	....	....	....
	6	War Eagle.....	Omaha	4,668	....	....	....	....
	8	Richmond	Fort Buford.....	65,668	....	....	....	....
	8	....do	Camp Cooke.....	130,000	....	....	....	....
	8	....do	Fort Benton.....	100,000	....	....	....	....
	8	H. S. Turner.....	Fort Leavenworth..	142,976	....	....	....	....
	8	.....do	Omaha	8,087	....	....	....	....
	11	Yellowstone	Fort Leavenworth..	274,093	....	....	....	....
	11	Ida Fulton	Fort Benton.....	82,065	....	....	....	....
	11	Ida Fulton.....	Camp Cooke.....	113,403	....	....	....	....
	12	Tom Stevens.....	.....do	5,008	....	....	....	....
	12	.....do	Fort Benton.....	148,708	....	....	....	....
	14	Nora..	Fort Sully.....	4,992	....	....	....	....
	14	Nora	Fort Benton.....	175,000	....	....	....	....
	14	Nora	Fort Berthold.....	3,264	....	....	....	....
	14	Nora	Camp Cooke.....	134,347	....	....	....	....
	14	Imperial.....	Fort Berthold.....	4,476	....	....	....	....
	14	Imperial.....	Fort Benton.....	234,685	....	....	....	....
	14	....do	Fort Buford.....	8,692	....	....	....	....
	14	....do	Camp Cooke.....	109,111	....	....	....	....
	18	Montada	Omaha	109,413	....	....	....	....
	18	Paragon.....	Fort Buford.....	309,982	....	....	....	....
	18	....do	Fort Berthold.....	261,845	....	....	....	....
	18	....do	Fort Rice.....	108,139	....	....	....	....
	18	....do	Fort Sully.....	119,793	....	....	....	....
	18	Montana	Fort Leavenworth..	.....	....	....	5	....
	18	Evening Star.....	Fort Berthold.....	407,270	....	....	....	....
	18	.....do	Fort Rice.....	100,643	....	....	....	....
	25	Zephyr.....	Camp Cooke.....	690	....	....	....	....
	22	Dictator	Fort Sully.....	377,585	....	....	....	....
	23	Zephyr	Fort Benton.....	130,000	....	....	....	....
	20	Glasgow.....	Omaha	59,768	....	....	....	....
	24	Yellowstone	Fort Leavenworth..	92,026	....	....	....	....
	22	Mary McDonald....	Fort Berthold.....	678,888	....	....	....	....
	25	.....do	Fort Rice.....	72,050	....	....	....	....
	18	Montana	Omaha	1,450	....	....	....	....
	25	City of Pekin.....	Fort Buford.....	553,424	....	....	....	....
	25	Columbian	Omaha	214,623	....	....	....	....
	25	T. L. McGill.....	Fort Sully.....	104,487	....	....	....	....
	28	.....do	Fort Berthold.....	730,125	....	....	....	....
	28	H. S. Turner.....	Omaha	106,069	....	....	....	....
	31	Jennie Lewis.....	Yancton	21,938	....	....	....	....
	31	.....do	Fort Randall.....	5,176	....	....	....	....
	31	.....do	Fort Sully.....	707,839	....	....	....	....
	28	H. S. Turner.....	Omaha	600	....	....	....	....
June	1	W. J. Lewis.....	Fort Leavenworth..	3,112	....	....	....	....
	4	Stonewall.....	Omaha	307,271	....	....	....	....
	4	.....do	Fort Leavenworth..	752	....	....	....	....
	7	Isabella	.....do	18,713	....	....	....	....
	6	War Eagle	Omaha	23,080	....	....	....	....
	6	Montana	Fort Leavenworth..	2,464	....	....	....	....
	6	....do	Omaha	301,954	....	....	....	....
	12	Glasgow.....	.. do	291,361	....	....	....	....
	12	W. J. Lewis.....	Fort Leavenworth..	24,862	....	....	....	....
	14	Columbian.....	Omaha	47,176	....	....	....	....
	17	Last Chance.....	Fort Sully.....	5,084	....	....	....	....
	17	Last Chance.....	Fort Rice.....	104,591	....	....	....	....
	17	.....do	Fort Berthold.....	86,554	....	....	....	....
	17	.....do	Fort Buford.....	27,885	....	....	....	....

List of government freight shipped up the Missouri river, &c.—Continued.

Date.	Name of steamer.	Destination.	Pounds weight.	Horses.	Mules.	Ambulances.	Wagons.
June 18	Kate Kinney	Omaha	257,918	....	....	....	....
19	Isabella	...do	171,144	....	....	....	....
22	Stonewall	...do	789,933	....	....	....	....
24	Deer Lodge	Camp Cooke	102,644	....	....	....	....
22	W. J. Lewis	Fort Leavenworth	8,544	....	....	....	....
24	Deer Lodge	Fort Benton	59,735	....	....	....	....
25	Montana	Omaha	496,339	....	....	....	....
26	H. S. Turner	...do	435,116	....	....	....	....
26	.....do	Fort Leavenworth	8,681	....	....	....	....
30	Cornelia	Omaha	170,319	....	....	....	....
July 3	Mountaineer	Fort Berthold	227,605	....	....	....	....
3	.....do	Fort Rice	290,097	....	....	....	....
3	.....do	Fort Sully	7,656	....	....	....	....
3	.....do	Fort Randall	7,644	....	....	....	....
3	Mountaineer	Yancton	25	....	....	....	1
2	Carrie	Fort Sully	83,822	....	....	....	....
2	Carrie	Fort Buford	400,217	....	....	....	....
4	Only Chance	Fort Sully	50,340	....	....	....	....
4	.....do	Fort Rice	104,450	....	....	....	....
4	.....do	Fort Buford	4,340	....	....	....	....
3	W. J. Lewis	Fort Leavenworth	137	....	....	....	....
5	Kate Kinney	Omaha	14,875	....	....	....	....
6	Huntsville	Fort Benton	2	....	....	....	....
6	.....do	Fort Rice	97,260	....	....	....	....
6	.....do	Fort Berthold	2	....	....	....	....
6	.....do	Fort Sully	8	....	....	....	....
9	Columbian	Omaha	53,548	....	....	....	....
12	Stonewall	...do	1,035	....	....	....	....
13	W. J. Lewis	Fort Leavenworth	107,127	....	....	....	....
16	H. S. Turner	....do	1,710	....	....	....	....
16	.....do	Omaha	76,375	....	....	....	....
19	Glasgow	...do	148,875	....	....	....	....
24	Kate Kinney	...do	23,371	....	....	....	....
24	G. B. Allen	Fort Leavenworth	178,921	....	....	....	....
27	Columbian	Omaha	122,627	....	....	....	....
27	....do	Fort Leavenworth	93,179	....	....	....	....
29	Deer Lodge	Fort Berthold	175,609	....	....	....	....
29	.....do	Fort Sully	13,380	....	....	....	....
29	.....do	Fort Rice	16,500	....	....	....	....
29	.....do	Yancton	7,636	....	....	....	....
31	H. S. Turner	Omaha	82,767	....	....	....	....
31	H. S. Turner	Fort Leavenworth	93,838	....	....	....	....
August 1	Amaranth	Fort Rice	61,031	....	....	....	....
1	.....do	Fort Stevenson	251,600	....	....	....	....
8	Glasgow	Omaha	.....	....	81	....	....
8	....do	Fort Leavenworth	656	....	30	....	....
6	W. B. Dance	.....do	88,064	....	....	....	....
6	.....do	Omaha	909	....	....	....	....
10	Mary McDonald	Fort Rice	3,773	....	....	....	....
10	.....do	Fort Sully	2,848	....	....	....	....
10	.....do	Fort Stevenson	240,648	....	120	....	20
12	Montana	Omaha	61,789	....	....	....	....
12	....do	Fort Leavenworth	262,919	1	....	....	....
13	G. B. Allen	.....do	73,347	....	....	....	....
14	W. J. Lewis	.....do	282,276	....	....	....	....
16	Kate Kinney	Omaha	14,344	....	....	....	....
16	.....do	Fort Leavenworth	163,616	....	....	....	....
22	H. S. Turner	.....do	243,256	....	....	....	....
20	Columbian	.....do	165,041	....	....	....	....
20	.....do	Omaha	2,354	....	....	....	....

List of government freight shipped up the Missouri river, &c.—Continued.

Date.	Name of steamer.	Destination.	Pounds weight.	Horses.	Mules.	Ambulances.	Wagons.
August 22	H. S. Turner.....	Omaha	158,402	....	....	....	....
24	W. J. Lewis.....	Fort Leavenworth..	233,750	....	....	....	....
24	Ben Johnson.....	Omaha	147,521	....	....	....	....
26	Glasgow	...do	268,639	....	....	....	....
29	G. B Allen..	Fort Leavenworth..	142,011	....	....	....	....
31	Octavia	Omaha	107,740	....	....	....	....
31	...do	Fort Leavenworth..	.....	1	....	....	....
Sept. 2	Lady Grace.....	Fort Stevenson.....	160,848	....	....	....	....
2	.....do	Fort Sully.....	50,288	....	....	....	....
4	W. J. Lewis.....	Fort Leavenworth..	24,735	....	....	....	....
4	Cornelia.....	Omaha	193,689	....	....	....	....
7	Amelia Poe.....	Fort Randall.....	8,053	....	....	....	....
7	.....do	Fort Sully.....	30,402	....	....	....	....
7	.....do	Fort Rice.....	235,527	....	....	....	....
13	Sam Gaty.....	Omaha	225,071	....	....	....	....
14	G. B. Allen.....	...do	247,773	....	....	....	....
14	.....do	Fort Leavenworth..	5,995	....	....	....	....
19	Mountaineer	Fort Randall.....	99,589	....	....	....	....
20	Antelope	Omaha	22,884	....	....	15	6
20	....do	Fort Leavenworth..	41,259	....	....	....	....
20	Deer Lodge.....	Omaha	42,670	....	....	....	....
20	.....do	Fort Leavenworth..	12,125	....	....	....	....
21	Mountaineer	Yancton	35	....	....	....	....
20	Ben Johnson.....	Fort Leavenworth..	6,635	8	....	....	....
	Total	.....	27,914,077	82	394	26	70

K 14.

PITTSBURG, PENNSYLVANIA,
February 18, 1868.

Proceedings of a board of engineers convened at Pittsburg, Pensylvania, on the 6th of February, 1868, by virtue of the following orders:

HEADQUARTERS CORPS OF ENGINEERS,
Washington, September 5, 1867.

COLONEL: Your letter of the 31st ultimo has been received. You are authorized to convene the board of engineers constituted by Engineer Orders No. 18, dated March 22, 1867, at Pittsburg, Pennsylvania, on the 30th instant, or as soon thereafter as the duties of the several members will permit, for the purpose of examining and reporting upon the river channeler of Colonel W. H. Nobles. Would it not be advantageous to the interests of the several works to delay the meeting until the close of active operations?

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General Commanding.

Colonel J. N. MACOMB,
Corps of Engineers, Box 825, *Cincinnati, Ohio.*

HEADQUARTERS CORPS OF ENGINEERS,
Washington, September 24, 1867.

COLONEL: The inclosed letter from Brevet Major General G. K. Warren, major of engineers, with accompanying papers relating to the channeler of Colonel W. H. Nobles, is

transmitted to you, that it may be laid before the board of engineers constituted by Engineer Orders No. 18, dated March 22, 1867, whenever you shall convene the same under the authority already granted.

By order of the Chief of Engineers.

Very respectfully,

I. C. WOODRUFF,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A., Assistant.

Colonel and Brevet Colonel J. N. MACOMB,
Corps of Engineers, Box 825, Cincinnati, Ohio.

[Orders.]

OFFICE OF THE WESTERN RIVER IMPROVEMENT,
Cincinnati, Ohio, December 28, 1867.

The board of engineers constituted by Engineer Orders No. 18, dated Washington, D. C. March 22, 1867, will meet at Pittsburg, Pennsylvania, on Thursday, the 6th of February, 1868, or as soon thereafter as practicable, in conformity with the authority conveyed in the accompanying letter of the 5th of September, 1867, from headquarters corps of engineers.

J. N. MACOMB,
Col. of Engineers and Bvt. Col. U. S. A., President of Board.

Brevet Major General J. H. WILSON,
Lieutenant Colonel 35th Infantry.
Brevet Major General G. K. WARREN,
Major Corps of Engineers.
W. MILNOR ROBERTS,
Civil Engineer.
Brevet Lieut. Colonel PETER C. HAINES,
Captain Corps of Engineers.

The undersigned, having met at Pittsburg, Pennsylvania, on the 6th day of February, 1868, in obedience to the above orders, and for the purpose therein set forth, have the honor to submit the following report:

For several months of nearly every year the navigation of the Mississippi river and its principal tributaries is rendered exceedingly difficult, and in some instances almost entirely suspended by the shallowness of the water and the interposition of sand-bars. Between these bars the pools are usually deep enough for the ordinary purposes of navigation, but where the bars occur the water is not generally more than two and a half or three feet deep, and is frequently not more than eighteen inches. From this general statement it will be seen that, for the purpose of facilitating navigation, there is a well-determined necessity that the government shall adopt an efficient plan for the removal of sand-bars or the deepening of the channel over them.

The laws governing the formation of sand and gravel bars have been investigated by the members of this board with great care, as well as by other engineers in all parts of the world. Without entering into a discussion of the causes which they control, it is sufficient for our purposes here to say that the causes are unceasing in their effect during the season of freshets and high water, varying with the rise and fall and with the changing conditions of the shore and islands.

So long as rivers continue to flow, they will continue to exert their influence in the formation and modification of sand-bars; and although channels may be cut through the bars during low water, they will be obliterated by the next freshet, and injured, in many cases, by the slightest swell in the river. No fact is better established than this, from which it will be seen that whatever machine is adopted for the purpose of deepening the water over sand-bars, hourly and yearly undergoing change in location and shape, must be applied after every flood, and be

maintained by annual appropriations. It becomes, therefore, a matter of great importance that this machine shall be as economical as possible in construction and operation, simple in its character, not easy to get out of order, strong and staunch in all its parts, and that it shall produce its useful effect readily, rapidly, and cheaply. For the purpose of facilitating our examination of the plans and models which have been presented for the consideration of this board, we have decided that the following conditions must be kept continually in mind, viz:

First. Every channeling machine designed for use on the Mississippi river or its navigable tributaries must be economical in its cost and operations, counting time in moving from place to place, as well as time consumed in working upon the channel.

Second. While improving navigation for one class of vessels or business, it should not make it worse than before for any other class, but should leave the new channel in the greatest state of permanency practicable at the particular locality during the lowest stage of water.

Third. That while working it shall obstruct navigation as little as possible for all vessels and rafts, and should be capable of being readily withdrawn from the channel.

Fourth. That, besides being a channeler, it should, if practicable, be made to answer the purpose of a snag-wrecking and tow boat.

In applying these conditions to the machines under consideration, it should be premised that great difficulty has been necessarily encountered in predicting, from drawings or small working models, what will be the precise action of the machines themselves while engaged in the work for which they are intended, surrounded by the peculiar circumstances and difficulties of actual service. Inventors, as a rule, are usually men of sanguine expectations, and frequently have greater confidence in the performance of their inventions than other people have; but in the cases under consideration we have carefully weighed all the evidence presented, and have striven to arrive at correct conclusions.

The board first examined the drawings of a snag, wrecking, and dredging boat, submitted by Mr. C. E. Pierce, civil engineer, designed more especially, however, for the removal of sand-bars. The boat is an ordinary river steamer, arranged with two double-acting steam-pumps, which supply a head of water which is forced through and from a set of nozzles arranged in a water-line about the bow of the boat. The nozzles are three inches in diameter and 28 in number. The mode of operation is as follows: The steamer being on the up-stream side of the bar, is run down toward it at the point where it is designed to cut the channel. A strong jet of water is then forced through the nozzles by means of the steam-pump, with power sufficient to wash away the sand in the immediate vicinity of the nozzles. The sand is moved forward by this current, aided by the flow of water in the river, and by the nozzles at and near each extremity of the circular row thrust off at the side of the boat, thus opening a channel of width proportionate to the length of the row or width of the boat. In order to cut a channel of any desired width, the boat must be brought into operation against the sides of the new channel by hedging.

Mr. C. E. Pierce having explained the mode of operating his machine, made the following proposition:

I propose to furnish a machine such as is represented by the drawing here below.

If the government will furnish a boat of about 150 feet long and 30 feet beam, I will put in the double-acting force-pumps with 13-inch exhaust leading to 3-inch pipes, giving jets from a water-line around and beneath the bows, so as to stir up the sand when the pumps are set in motion, and thus wash a channel through such sand-bars as are met with on the

Mississippi, Missouri, or Arkansas rivers. My terms are, that if the machine shall prove a failure its cost shall be nothing more to the government than my pay as an assistant on the western river improvements during the two or three months' time which the construction will probably require; and if it should prove as great a success as I believe it will be, then the government shall pay me for it a price not to exceed double of my actual outlay for it, and in no case to exceed the sum of $20,000.

C. E. PIERCE.

The board also examined the drawings and specifications of a machine invented by Mr. Nelson Vandeventer, of New Albany, Indiana, for excavating in water-courses having currents. A copy of which is appended hereto, marked A.

There was also submitted to the board for their inspection the plan of Mr. E. B. Bishop to fix two large screws obliquely, one on each side of a steamboat's bow; these, driven by the engine, draw the boat through the water, and on striking a sand-bar throw the material on each side, making a way through it equal to their greatest width apart.

General Warren also submitted for the consideration of the board the plan devised by the late Colonel S. H. Long, United States engineers. The plan of Colonel Long is to attach scrapers to a frame which is suspended and handled by proper gearing and rigging to the stern of any blunt-bowed boat of a proper size for the river navigated. A boat constructed to act as a snag-boat could also have this attachment. She has her own propelling power, and is as easily handled as any steamboat.

General Warren also submitted an extract from the report of his assistant, Mr. H. C. Long, civil engineer, giving a detailed account of the construction of the scraper devised by the late Colonel Long, and its adaptation, the past season, to the steamboats Montana and Caffrey, during the low water on the Mississippi river. The extract is appended hereto, marked B.

Colonel Macomb submitted to the board a plan devised by Mr. E. P. Ligons, called a submarine plow, described in C.

The board also examined the drawings and models of Colonel W. H. Nobles's channeler, which may be generally described as follows: It is a small steamer, with an apparatus attached to it for clearing or cutting out channels through bars of sand or gravel or hard pan; this apparatus is an elongated drum placed upon the boat in lieu of the "paddle-wheel" of the ordinary "stern-wheel" steamer. The drum is strongly made of boiler iron, and has a series of plows and scrapers upon its convex surface. These plows and scrapers are arranged upon spiral lines leading outward from, and symmetrically situated with reference to, a central plane perpendicular to the axis of the drum. The drum is suspended by strong journals near its extremities, and is caused to revolve by the action of two engines of about 35 horse-power each. The driving engines act upon the drum through a system of gearing leading to a great cog-wheel which is fixed as a belt around the middle of the drum.

The action of the plows and scrapers, it is claimed, will be to move the sand and water outwardly from the middle of the drum, washing the sand away by the current of the stream, aided by the current which the machine causes, and thus leave a channel-way of awidth equal to the length of the drum.

The mode of attacking a river sand-bar is to drop down upon it, on the up-stream side, with the boat headed up-stream and the drum revolving so as to tend to drive the boat away from the bar or shoal, but she is held in contact with the bar by anchors and hawsers laid out in the direction of the channel to be cut, and by horizontal windlasses

winding upon the hawsers to draw the boat stern foremost through the channel as it is cut by the revolving drum. As an auxiliary power for keeping the boat in position, there are wings attached to the sides of the hull; and which can be set at any angle therewith so as to catch the current.

The boat is provided with water-tight compartments, into which water may be admitted and pumped out at pleasure, so as to increase or diminish the draught of the boat within the probable limits of depth required in the channel through the bar.

Its inventor asserts his belief that one of the machines, with all its appurtenances complete, 90 feet long, 30 feet wide, and with a cutting or channeling drum 40 feet long, can be built for $20,000; and claims that it will be capable of cutting a channel 40 feet wide and 3 feet deep, in a sand-bar at the rate of 100 running feet every 40 minutes; the same size through gravel at the rate of 100 feet every 60 minutes; and through clay or hard pan at the rate of 100 feet in 80 minutes. That 12 men will be sufficient to handle and operate the machine in ordinary use, that it will throw the water and excavated materials from the end of the drum with such a velocity as to spread the latter out and carry them beyond all danger of being thrown back into the channel; that his machine will consume only five tons of coal per day, and that in changing station can be propelled by the same machinery at the rate of eight miles per hour. He also claims that, with a machine of the size just mentioned, he can, by making successive cuts, excavate a channel of any necessary width (and depth) from 40 to 120 feet, and even wider if required.

Colonel Nobles, and Mr. Rees of Pittsburg, Pennsylvania, also submitted a proposition to the board, which is herewith appended, marked B and C.

For the illustration of this machine and its method of operating, the inventor exhibited a working model 5 feet long, and 18 inches wide, with all the other parts, including engines, windlass, gearing and excavating drum complete—assumed to be on a scale of three feet to one inch—which would represent a vessel 180 feet long, 40 feet wide, and a cutting or excavating drum 54 feet long. A bed of partially hardened plaster of Paris was prepared, the boat mounted upon wheels running upon horizontal ways, was kept or "fed" to its work by ropes attached in advance and rear, passing around two horizontal capstans on the model—a full-size channeler is designed to be kept to its work by these horizontal capstans, aided by two wings catching the current in the river—and the machinery was put in motion by steam brought by an India-rubber pipe from a large foundry boiler near by.

The plaster-bed or bar was cut through by the plows and excavators in the drum, and the excavated materials were thrown out to the right and left and piled up in a ridge alongside of and parallel with the boat. The operation was rapid and complete, and was intended to represent a cut of four and a half feet in depth. It also worked through a bed of gravel partially covered by water, and in this case the excavated materials were piled up as before, although not quite so high. There was no current in the water covering the small bed of gravel, both being inclosed by a water-tight box carrying the machine. While the machine was approaching the gravel, the excavating drum revolving at a high velocity, the water was thrown out to the right and left, creating a perceptible current, but it is not believed that in the case of a full-sized machine, operating in an ordinary sand-bar, that this velocity, superadded to that of the natural current, could be depended upon to carry

the excavated materials out of the way of the new channel after they have been thrown from the end of the drum. The question immediately presents itself, will a full-sized machine do proportionately as well working on a sand-bar, and can it be depended upon to cut a channel of any required width and depth as claimed by the inventor?

After a careful study of this model, together with the plans and opinions of Mr. Nobles, we have to say that, while it is possible that the full-sized machine may do all that it is claimed for it, this has not been satisfactorily proven, and we see no means by which this can be done except by the exhibition and trial of such a machine in the work of excavating channels through sand-bars under all of the peculiar circumstances and difficulties likely to be encountered in actual service. The working of the model proves nothing more than that it is capable of digging through bars of plaster and gravel, and that it will throw the excavated materials into ridges to the right and left of the cut. The same objection holds good in regard to all the plans, except Colonel Long's, that has been submitted to the board.

For the foregoing reasons we cannot recommend the construction of Nobles's machine at the government's expense. Nor can we undertake to give a definitive decision between it and the other machines presented for our consideration; neither do we think it possible for such a decision to be given till an actual trial in deepening rivers shall have been made by the various machines designed for that purpose. One member of this board has given an extended trial to Long's scraper, in the improvement of the Mississippi river, and has found it to answer sufficiently well for all purposes, until it can be replaced by the best machine which can be devised. We would, therefore, suggest, in lieu of any special recommendation, that, in order to encourage inventors, and to secure for the government the most efficient means of improving the navigation of western rivers during seasons of low-water by removing sand-bars, snags, and wrecks, a prize of $100,000, or other suitable sum, should be offered by the government for the invention and construction of the machine best adapted to these purposes, according to the conditions hereinbefore given. We would further recommend that due notice of this prize shall be given by advertisement; that a board of engineers shall be appointed to decide upon the machines presented, under such instructions as the engineer department may give, and at such time and place as may be fixed; and finally, that the prize of $100,000 shall be considered to be final and complete compensation to the inventor of the successful machine for all the rights to which he would be entitled under the United States patent laws, provided that the actual cost of the successful machine shall be paid by the government over and above the amount of the prize herein recommended.

All of which is respectfully submitted.

J. N. MACOMB,
Colonel of Engineers, Brevet Colonel United States Army.
J. H. WILSON,
Lieutenant Colonel 35th Infantry, Brevet Major General U. S. A.
G. K. WARREN,
Major of Engineers, Brevet Major General U. S. Army.
W. MILNOR ROBERTS,
United States Civil Engineer.
PETER C. HAINES,
Captain Engineers, Brevet Lieutenant Colonel U. S. A., Recorder.

A.

Excavators for water-courses having currents.

NELSON VAN DEVENTER, of New Albany, Indiana, letters patent No. 2,456, dated October 8, 1861.

SPECIFICATIONS.

Fig. 1 is a side elevation.

Fig. 2 is a top view.

Fig. 3 is a longitudinal sectional view of the excavator F.

The drawings show only the stern of the vessel, on which the excavator is supposed to be mounted. Such part required for the location of the steam-engine and boilers, necessary to produce the power, is omitted, this omitted section being similar to the part of the vessel making the bow, and other embodiments, as a whole, with the steam-engine or engines and boilers so placed as to cause the power to turn the shaft *a*, which can be done by direct action, or driving gearing, which drives the wheel *x* on the same shaft.

The shaft, also lying across the deck, and marked *b*, on which are winding barrels *ss* and perrol *y*, can be placed in other positions if necessary, to be out of the way in making the attachment of the engine to the shaft *a*. The use of the winding barrels is to change the position of the excavator, so the depth of cutting can be changed, and also elevated for the purpose of moving the vessel or making any repairs which may be required, the chains *e* being attached to the frame *d*, and passing over pulleys in posts P and passing around the winding barrels.

The projections marked *g* (see Fig. 2) represent the guards of the vessel. The shaft *a* passes in each side to the full width of these guards, and on the ends are mounted the side frames *c*, which support the frame *d*, and joined by stays to make a strong framing, and with angular supports to hold the cutting cylinder or excavator *f f'*. This cylinder is mounted on the ends of these frames, the shaft passing through it and making its center, having journals fitting into bearings made in the frames. The other ends of the frames are similarly attached to shaft *a*.

On shaft *a* and the shaft *f'* (making the center for the excavator) are wheels *r*, to carry a pitch chain *z* to cause the excavator to revolve with shaft *a*. If it is deemed preferable to use a rigid connection, a shaft can be used instead of the chain, having bevel gearing with corresponding wheels to act on it to bring the same movement.

A is the body of the stern, having a rudder *r*; *o o* designate the frames supporting the shafts *a* and *e*.

The manner of constructing the excavator is as follows: *f* is a central shaft of a length to suit the width of the boat, and of sufficient thickness for strength, is journaled in the lower end of the frame *d*; *f f* represents a series of serrated metallic disks, the teeth of which are turned alternately in opposite directions (see Fig. 2) in a manner similar to the setting of circular saws, but to a greater degree. The disks *f* are placed upon the shaft *f'*, as shown in Fig. 3, with their teeth in parallel positions, and kept at a suitable distance apart by rings or chocks *i i*, the exterior rings being attached to the shaft to secure the whole in position.

The obliquity of the teeth causes them to cut a width equal to the distance between the disks, so as to act thoroughly upon the earth throughout the entire length of the excavator.

This construction of excavator is found highly efficient in raising deposits in channels and separating the earth into small particles so that it may be carried off by the current.

What I claim as new and desire to secure by letters patent is:

The combination of the rotary shaft *f'*, disks *f*, with teeth set obliquely, and rings *i*, securing the said disks at a proper distance apart, the whole being constructed and arranged as herein shown and described, and operating in connection with the steamboat A, pivoted frames *c d*, and hoisting apparatus V S *c p*, in the manner and for the purpose set forth.

This excavator, running 100 revolutions per minute and cutting half an inch to the cutter, 29 cutters to the disk, the disks 40 inches in diameter, will do the work of 249 common bucket dredging machines. For further information address Nelson Van Deventer, St. Louis, Missouri.

[For sketch of Nelson Van Deventer's excavator for water-courses having currents, Figs. 1, 2, and 3, see original.]

B.

PITTSBURG, *February* 8, 1868.

SIR: I agree to build a dredge-boat, after the model and description given by Colonel Nobles, under his supervision, and to be constructed similar in style to the drawings and specifications now lying before the board of United States engineers; and also aid him in giving the necessary proportion and strength to the construction of said boat and machinery, so as to make it as near perfect to perform the duties as possible, with a view to satisfying the board of engineers in its entire construction; and will charge $25,000 for its construction. And in case the dredge does not perform to the satisfaction of said board of engineers, and they should deem best to not use it, I will take and dispose of it to the best advantage, and bear one-half of the loss of depreciation, thus assuming one-half the risk in the experiment.

In my calculations I contemplate making the channeler about five feet wider than it is represented in Colonel Nobles's drawings.

Respectfully yours,

JAMES REES.

Colonel J. N. MACOMB,
President Examining Board U. S. Engineers.

C.

PITTSBURG, *February* 10, 1868.

SIR: Having expended no less than $8,000 in perfecting my plan of improving the channels of our western rivers, and being short of funds, I am unable to make such propositions as would be likely to be deemed sufficient by your board to secure the construction of a river channeler. Captain James Rees having kindly offered to submit a proposition, and his well-known ability to perform the work, I desire the board to consider Captain Rees's proposition for me, instead of any that can be made by myself.

I am, very respectfully, your obedient servant,

W. H. NOBLES.

Colonel J. N. MACOMB,
President Board U. S. Examining Engineers.

D.

UNITED STATES ENGINEER OFFICE, SURVEY AND IMPROVEMENT UPPER MISSISSIPPI, MINNESOTA, WISCONSIN, AND FOX RIVERS, &C.,
Saint Paul, December 31, 1867.

GENERAL: I have the honor to report my connection with the introduction and use of the scraper invented by the late Colonel Stephen H. Long, United States engineers, as follows:

On the 12th of last August, an arrangement was made with Mr. D. S. Stombs, machinist of this city, for the construction of three of the above scrapers—two of larger dimensions, having five cutters, and one smaller, with four cutters. The former to cost $700 each; the latter $666. This arrangement was faithfully carried out by Mr. Stombs, and the work delivered as specified. The accompanying drawing, marked No. 1, shows all the details of construction of the smaller scraper. The larger differed in no respect except that at the base of the triangle there were five semicircular cutters instead of four. The general plan of the whole apparatus will be found to be the same as that recommended in my report to you of December 26, 1866, (see H. 4, Doc. No. 58, pp. 671–73,) and is distinctly set forth in the accompanying drawings and explanations. (See drawings, Nos. 1 and 2.)

DRAWING NO. 1.—EXPLANATION.

FIG. 1.—Front view of scraper, with the buckets or cutters attached, platted on a scale of four feet to one inch. A B C, triangular frame of scraper, of oak, with its bands, braces, bolts, &c., the drag-chains are fastened at B and C; D D D D, the buckets or cutters, of boiler iron; E, bowsprit of boat, showing position of sheaves and chain, by which the scraper is raised or lowered when operating on the bars.

FIG. 2.—Isometrical view of lower part of scraper, on same scale as above.

N. B.—The same letters refer to the same parts of the scraper in all the drawings.

[For Colonel Long's scraper, drawing No. 1, Figs. 1 and 2, see original.]

DRAWING NO. 2.—EXPLANATION.

(Side view section, and details of scraper, scale four feet to one inch.)

FIG. 1.—Side elevation of frame and cutters or buckets. A B C, triangular frame of oak, with its straps, bolts, braces, &c.; D, bucket; E E, bowsprit; *g*, friction rollers, to facilitate raising and lowering the scraper.

FIG. 2.—Portion of base of scraper frame, showing method of bolting cutters or buckets, D D, to lower beam by their flanges.

FIG. 3.—Section and side view of same.

FIG. 4.—Under side of lower beam, B C, showing position of iron straps and eye-bolts at B and C, to which the drag-chains for hauling the scraper over the bars are attached, also position of bolts for fastening on the buckets or scrapers, indicated by the small circles thus, "o."

[For Colonel Long's scraper, drawing No. 2, scale four feet to one inch, Figs. 1, 2, and 3, see original.]

On the 10th of September you arrived from St. Louis, Missouri, with the steamer Montana, purchased at the same time with the C. J. Caffrey,

for testing the practical advantages and economy of Colonel Long's invention, and for other purposes; soon afterwards I received orders to fit one of the larger scrapers to the former boat. Measurements were taken and drawings made for this purpose, Mr. Stombs having been engaged as master mechanic. The entire apparatus was mounted, and the Montana reported ready for service, by the 1st of October. Accordingly, she took her departure from St. Paul for experimental operations on the bars below, on the 5th of the same month, under your personal supervision.

The accompanying drawings, Nos. 3 and 4, show correctly the method of attaching the scraper to the Montana, and the general appearance of boat and apparatus when ready for work.

DRAWING NO. 3.—EXPLANATION.

(Scale, eight feet to one inch.)

FIG. 1.—Plan of bow of steamer Montana, showing position of main deck and manner of fastening bowsprit to same, also, position of capstan, chains, falls, tackle, for raising or lowering scraper.

FIG. 2.—Section on side view of same. This figure shows the scraper hoisted up and tilted back in convenient position for steamers when under way, running from point to point, engaged in towing or snagging. When thus raised, the scraper does not interfere with the operations or ordinary business of any steamer to which it may be attached.

[For Colonel Long's scraper, drawing No. 3, scale eight feet to one inch, Figs. 1 and 2, steamer Montana, see original.]

DRAWING NO. 4.—EXPLANATION.

Outline sketch in perspective of United States steamer Montana, showing relative position and dimensions of scraper and steamer.

Principal dimensions of steamer as follows: Length on deck, 210 feet; breadth of hull front of water-wheels, 35 feet; breadth of hull front of water-wheels, across guards, 48 feet; depth of hold, 5½ feet; tonnage, custom-house measurement, 484 tons; draught, with fuel, &c., on board, ready for operation on bar, 33 to 36 inches. Three boilers, 20 feet long, 3 feet 6 inches in diameter, 5 flues each. Two engines, 20 inches in diamater, 7 feet stroke, (cylinder,) doctor, nigger, or hoisting engines, &c. Scraper, 16 feet base, 16½ feet high; 5 buckets, or cutters, weight about 6,500 pounds—3¼ tons.

[For Colonel Long's scraper, drawing No. 4, Montana, see original.]

The accompanying drawings, 5 and 6, show the method of attaching the scraper to the Caffrey. It will be observed to differ in a few particulars from that of the Montana. The timbers of the bowsprit are longer and carried further back, and but one cross-piece introduced. We were enabled to effect this improvement by altering the position of the capstan, and shortening the connection with the hoisting engine before alluded to.

[For Colonel Long's scraper, drawings Nos. 5 and 6, see original.]

DRAWING NO. 5.—EXPLANATION.

Section of steamer Caffrey, from bow to near center of boilers, on a scale of eight feet to one inch.

This drawing shows the position of the hoisting engine, or nigger, H H, its connection with the capstan J by shafts and cog-wheels under the main deck, whereby the scraper is raised and turned on both boats—Montana and Caffrey—and the scraper towed into a bar or reef ready for operations in reducing same, exactly in the manner used in the experiments detailed in this report.

DRAWING NO. 6.—EXPLANATION.

Outline sketch of C. J. Caffrey in perspective, showing relative position and dimensions of scraper and steamer.

I wish it to be understood that the adaptation of the Long scraper to the Montana and Caffrey, and the mechanical arrangement by which it is raised and towed, is not considered the best that could have been devised, but the one by which we could most readily operate with, this same season.

The bowsprit E E, drawing 7, (see original,) can be built in the frame of the boat, so that the top of the timbers (bowsprit E E) may be flush with the line of the deck. The scraper frame to be raised and lowered by the horizontal drum K, worked by the hoisting engine as before illustrated. (drawing 5.) The chains or falls *e e*, being entirely under the deck, leaving the latter unincumbered, and the capstan J and bits L (drawing 7) free to be used as such contrivances are intended on ordinary steamboats, but time would not allow of such machinery being employed heretofore.

The Montana was built for the Missouri river trade, and the C. J. Caffrey for the Ohio, Cumberland, or Tennessee.

The application and use of the scraper on these boats shows that it can be applied with equally good effect to the boats now used on those rivers to remove the shoals and bars which obstruct their low-water navigation, and in fact to all other western rivers as well as the upper Mississippi.

The method of operating the scrapers on the Montana and Caffrey is precisely the same as described in my report of December 26, 1866. (See H. Ex. Doc. No. 58, pp. 70.) It may be well to repeat it here, viz:

The scraper being applied to the bow of a suitable dredge-boat or tug, by means of a bowsit, drag-chain, hoisting and lowering warp, and other tackle adapted to its use, is conyed to the head or margin of the shoal to be dredged; it is then towed to the bed or bar, d the wheels of the steamer are turned backward in a direction to drag the scraper across shoal, the steamer moving stern foremost with the current of the water if there be any h current.

Having been dragged entirely across the shoal, the scraper is again hoisted out of the ter and the steamer returns bow foremost to the place of beginning. The operation is in resumed as before, and continued till a channel of the required depth and width shall e been opened.

The action of the scraper is twofold: first, it cuts up and loosens the terial of which the bar is composed, then conveys it down stream and posits it in deep water. It does not excavate a channel by throwing ridges or windrows on either side, but by a succession of drags or pes removes entirely the crust of the reef or bar, leaving it in a con-on favorable to a further improvement by the action of the current.

Respectfully submitted.

H. C. LONG,
United States Civil Engineer.

Major and Brevet Major General G. K. WARREN,
Corps Engineers U. S. A.

E.

E. T. Ligon's submarine plow. Patented September 17, 1867, No. 69,000.

This is a plow attached by timbers to the side of a steamer so as to make a furrow in the bottom of the bay or river to be deepened. Spiral springs are attached to the timbers holding the plow, so as to force it down to its work and make it adapt itself to the irregularities or undulations of the bottom.

There is a hose connected with the plow, by means of which it is calculated to force a stream of water into the furrow as fast as it is made, and thus to scatter the newly broken earth over the bottom, with the idea that by thus stirring it up it will be carried off by the current created by forcing water through the hose, or by the natural current of the stream, in the case of a river bar which it is desired to cut through.

APPENDIX L.

OFFICE OHIO RIVER IMPROVEMENT,
Pittsburg, Pa., July 15, 1868.

GENERAL: In obedience to instructions contained in circular of the engineer department dated June 10, 1868, I respectfully present the following annual report upon the surveys and works under my charge as superintending engineer of the Ohio river improvement.

In my last annual report, dated September 14, 1867, I took occasion to detail in full the various estimates called for to complete the improvements at each place, and referred at length to the general features of the several points requiring work, so that in the following it may not be necessary to more than refer to that report for some particulars.

SURVEY OF THE OHIO RIVER.

As mentioned in the last report, two surveying parties had been organized in June, 1867. One party, under Sigismund Low, esq., assistant United States civil engineer, began 271 miles below Pittsburg, at which point Captain Sanders and Mr. Fuller's survey terminated in 1844, and had by September 12 reached a point 73 miles above Cincinnati. The other party, at first under Mr. Livermore and afterwards under Mr. Day, assistant United States civil engineer, began at Cincinnati, and at the same date had reached a point 20 miles above Louisville.

These surveys were continued until the end of the season, when the high water and cold weather interfered to prevent their further progress.

Mr. Low's party, after reaching Cincinnati, about the middle of October, leaving their floating boat, proceeded by rail to Evansville, Indiana, passing by Mr. Day's party, where they commenced, and had finished 43 miles below that point when they stopped for the season.

The party under Mr. Day, after reaching Louisville, resumed their survey below the falls. Their lines at that point were connected with those of General Weitzel, so that they omitted the falls. Through the courtesy of General Weitzel this office has been furnished with a large chart of the falls on an enlarged scale, which will be embodied in the charts and report of the surveys of the entire river when they are completed. Mr.

Day succeeded in surveying 108 miles of the river below the falls before he stopped for the season.

The distance surveyed by Mr. Low's party was 196 miles, from Carrion Ripple to Cincinnati, and below Louisville 43 miles, making a total of 239 miles.

The distance surveyed by Mr. Day's party from Cincinnati to Cloverport, Kentucky, including the falls, was 240 miles, or a total of 479 miles surveyed by both parties during the summer and fall of 1867, including seven miles surveyed at the falls by General Weitzel.

There yet remain about 250 miles of the river, between Louisville and Cairo, to be surveyed, viz: about 100 miles between Louisville and Evansville, and 150 miles between Evansville and Cairo.

The maps, &c., of the surveys so far made are completed with the exception of some soundings to be made by a special party during the season, which high water at the time prevented the regular parties from taking as they passed along.

Under date of January, 1868, I addressed the department a letter on the subject, stating the reasons why a full report on the surveys had better be postponed until these details were obtained and the entire river surveyed. Two parties are now about organized to continue the surveys, so that it is hoped a complete map and report of the river can be furnished after the close of the season of 1868.

The engineering and inspecting party under Thomas P. Roberts, assistant United States civil engineer, with the engineer steamer Tidioute, besides their regular duties have from time to time made some hydrographical and other surveys in connection with the works for the improvement of the navigation, particularly at Brunot's island, and at White's Ripple, a difficult piece of river 11 miles below Pittsburg, a complete map, showing every feature of interest for two and one-half miles, was made in June of this year. They were also engaged in making a table of the flow of the river at Pittsburg from calculations of the flow at different stages of the water from low water up to 22 feet in the channel, from which, with the assistance of the office record of heights of water, the weekly, monthly, and annual flow of the Ohio can be determined with more accuracy than has heretofore been attainable.

WORKS ON THE RIVER.

In my last annual report was presented the original estimated quantities required [contract prices, &c.] for the construction of a number of riprap dams planned to confine the water for the improvement of low-water navigation, as also to lengthen the period in which safe coal-boating could be carried on.

A table was also given showing the additional quantities [contract prices, &c.] required to complete said dams.

At the time of making that report it was expected that all these dams could be finished before the winter set in, but the almost unprecedented low condition of the river during the fall interfered so much that the contractors at some of the places were unable to move the stone away from the quarries. Again this spring the water remained high longer than usual, so that they were delayed resuming operations until within a few weeks. At the present time all of the unfinished contracts are being pushed rapidly to completion.

Standard showing the estimated amount of work done on the dams since last annual report to end of June, 1868.

Miles from Pittsburg.	Place.	Contractors.	Amount paid.	Yet to be paid.	Ten per ct. reserved.	Remarks.
11	White's Ripple	Swan & Fenton	$7,946 75	$5,596 25	$794 67	
18	Logstown	Routh & Lane	5,544 60	4,716 25	554 40	
85	Twin islands	Manful & Kerr, 1st	10,400 00			
		James Kerr, 2d	3,000 00			Contract closed.
107	Captina island	Routh & Lane	9,000 00			Contract closed.
112	Fish Creek island	Routh & Lane	6,210 00			Contract closed.
146½	Petticoat bar	King, Reinhart & Tripp	8,970 00			Contract closed.
174	Muskingum island	C. M. Cole	5,625 17	5,442 13	562 51	
185	Blennerhassett island	C. M. Cole	7,990 13	1,754 00	799 01	
214	Buffington island	J. J. Power, 1st	11,800 00			
		Charles Cable, 2d	9,887 50			Contract closed.

The table does not exhibit the June estimate, not yet paid, which will include a considerable amount of work, and which closes the contracts for Logstown bar and Blennerhassett's island. The July estimate will close the contract at White's Ripple, so that by the 1st of August Muskingum alone, of the original contracts, will remain to be closed.

White's Ripple, (11 miles from Pittsburg.)

It was hoped that the dams at this place could have been finished about the end of October, 1867, but the remarkable low water of the fall prevented work for several months, so that little was done after the date of last annual report, until the subsidence of the spring floods.

The dam, so far as finished, stood the winter freshets and ice gorges much better than could have been expected. The work is progressing favorably at present, and with no accident. The whole plan for improvement at present contemplated can be finished by the end of September. [The quantity of material remaining to close the first and second contracts will be all placed on the dams by the middle of July.] The necessity for the reconstruction of the old cross-dam, which entered into Captain Sanders's plan for the improvement of this place, was not so apparent last year; but frequent visits at different stages of water have shown that it will be necessary to partly rebuild it, to aid in checking the strong current, most dangerous at a coal-boat stage, which sets obliquely over the long dam running down the middle of the river. The construction of this dam involves an increase in the estimate heretofore made, of 2,500 cubic yards. Dredging off the point of a bar to relieve the current is advised also. This work will be confined nearly altogether to one place on the right bank of the river, 500 feet below the head of the dam, as shown on the charts; 2,500 yards of dredging in gravel is estimated for White's Ripple and vicinity. The whole system of dams here presents the appearance of breakwaters, the current to be guarded from carrying boats over dangerous rocks and bars, which formerly made the left half of the river dangerous for a mile down. Various considerations had to be taken into view, and until now no definite conclusion could be satisfactorily arrived at. It is a difficult place, difficult currents having to be accommodated up to a 10-feet stage, after which the river flows smoothly over its whole extent. The engineering and inspecting party have this summer made a complete survey of this locality, a map of which is now among the others in this office.

LOGSTOWN BAR, (18 miles below Pittsburg.)

As reported last year, the improvement of this place has made a safe, easy channel for the tow-boats. A number of experienced pilots have expressed themselves as greatly pleased with the work. The winter floods had the desired effect of washing away the sand ridge which had collected along the site of the old dam removed, making the channel over it deeper in that way, while the new dam became more consolidated from the sand, gravel, and debris washed into it, so that the stone placed on this spring to complete the dam had a good solid foundation. No further additional work for improvement at this place seems necessary. The dam was finished on the 1st of July, 1868.

TWIN ISLANDS, (85 miles below Pittsburg.)

The material estimated for dams at this place, in both contracts, was placed on the long dam from the Virginia shore, terminating on the head of the upper Twin island, on a whole length of 3,000 feet. As a general thing this dam has stood very well, the damage by undermining and settling being confined to the lower third, near the island end, where, for a distance of 500 feet, it has lowered itself in the sand. About 950 cubic yards will be required to raise the work to its original height. The dam has made for itself a good foundation, so that hereafter there will be less likelihood of its undermining.

Even with this break or low place, leaking a great deal of water, the navigation on the shoal has been better. In former reports to the department reference was made to the construction of a short dam to confine the water to the right of a bar, so as to concentrate all the water on the shoal, as otherwise a large quantity of the water sent down by the main dam is lost.

The necessity for this latter dam did not become evident until after the construction of the dam above. Seven hundred cubic yards will be required to construct it, or a total of 1,650 cubic yards for Twin islands.

CAPTINA ISLAND, (108 miles below Pittsburg.)

The dam at this place was completed late in the fall, so that it proved of advantage to navigation during last spring, the entire river being confined up to a seven-feet stage on the right or channel side of the island.

The dam was built very strongly, and has stood well, with the exception of about 150 feet, where it emerges from the water at a low stage on the island bar, where is seems to have settled down bodily. Otherwise the dam is benefited by becoming filled with gravel and sand, and is nearly water-tight. To rebuild the portions settled down, an allowance of 550 cubic yards has been made in the estimates below; also 500 yards of dredging, to straighten the channel and scrape away boulders, which still leave the navigation precarious for heavy-laden boats during the lowest water.

FISH CREEK ISLAND, (112 miles below Pittsburg.)

At date of last annual report but 800 cubic yards remained to be boated in. During the latter part of the fall the dam was finished. The contract was for 3,000 cubic yards, but the dam was built with 2,760 cubic yards, for which latter quantity the contractors were paid.

An ice-gorge, which settled during the winter at this dam, knocked off portions of the new stone before it had had time to become well settled. The whole damage done is, however, trifling, 400 cubic yards being all that is required to rebuild the work; and as the breaks have widened the base, the material to be put on will make a stronger dam than the original.

PETTICOAT BAR, (146½ miles from Pittsburg.)

The dams at Petticoat bar were reported as finished in last annual report. As mentioned in that report, the dams here remained intact, notwithstanding their having been subjected to heavier ice than has passed down the river for many years. At one point it shows the marks of having been rubbed, with only the effect of smoothing down the stone as though rolled with a heavy weight. No additional material seems to be required. A very noticeable improvement has been experienced at this place for the navigation of coal-boats at the lowest water, during which they can safely run, all the water being confined to the channel, and not, as heretofore, spreading over the shoal bars and old unfinished dam to the left of the channel.

MUSKINGUM ISLAND, (174 miles from Pittsburg.)

The same reason for the dams above not being finished apply to those further down the river, the water having remained remarkably low until late in the season. The work on the Muskingum dam is progressing favorably, the same contractor having also the dams at Blennerhassett's island. No damage was done to the dam during the winter, and it is likely that some surplus material will remain, which, as mentioned in last annual report, it will be well to apply to Blennerhassett's island dams to help make up the quantity required there, caused by damage during the winter.

BLENNERHASSETT'S ISLAND, (185 miles from Pittsburg.)

At date of last annual report but two dams were under construction at Blennerhassett's island, one at the head and another at the foot of the island, crossing to the towhead. Later, it was found necessary to further confine the water on the shoal, between a spur-dam at the foot of the towhead and semicircular wing-dam on the right hand. Both of these last were, however, of small dimensions. The three lower dams have all stood the winter very well, but, as anticipated last year, more material will be required on the head dam, for during the progress of the work, but more particularly in the winter, it settled down, and at several points gave way entirely, owing to the winter floods coming suddenly upon it before its base was fully filled out. Before the dam begins to overflow there is a difference of five feet between the pool above and that immediately below, and with three feet water flowing over it the force of the current is very powerful. There is no doubt it will stand after it becomes consolidated with gravel, which naturally washes into the dams; but to aid beforehand in this natural operation it is proposed to intermix brush with the stone, which will probably hold it, so that in a short period the whole dam will have become cemented with sand and gravel. Stones in some of the old dams built by Captain Sanders 24 years ago are so tightly imbedded in this natural cement that portions a foot square on the surface would require the aid of a crowbar to *loosen* them.

BUFFINGTON'S ISLAND, (214 miles from Pittsburg.)

There are two dams, as has been shown previously. The long Virginia chute dam has stood very well. It appears to be advisable to lengthen it out from its lower shoulder towards a bar around which the channel divides, and which neutralizes in part the evident good effect of closing the Ohio chute. The dam closing the Ohio chute was perfectly new, and although it has itself stood tolerably well, the water which at first ran through washed out a wide gap or channel, between its lower extremity and the head of the island, which in the nature of the case could not have been calculated upon, and happening in the middle of winter, it could not be repaired at a time when promptness might have materially checked the mischief. It is necessary now to carry this dam from its old terminus to the island in order to insure the permanent improvement of the new channel. The cutting process is not likely to renew itself at this point, as it has washed down to a more substantial foundation.

In all, 3,000 cubic yards is estimated to repair this dam and effect some improvement on the Virginia chute dam; and in addition, to straighten the channel through the lower portion of the shoal, where a difficult turn has to be made, 1,000 cubic yards of dredging may be required.

As a whole, it may be said the riprap dams have stood very well, when we take into consideration their newness and the sudden manner in which the winter floods set in. In many instances it appears necessary that additional work may be required to complete dams of this sort, after the first year, the first winter floods pointing out the vulnerable points.

REPAIRS OF WORKS, ETC.

According to orders from the department, in printed circular dated February 20, 1868, the amount required on these works to prevent them from deteriorating to June 30, 1869, has been carefully estimated.

In my monthly reports to the department, particularly that for June last, the damages to the dams by ice and the winter floods has been referred to in detail.

The following table exhibits the amount of work required at several of the points to prevent them from deteriorating, and to secure the channels, as well also as to repair the damages and floods of the winter.

Distance from Pittsburg.	Place.	Cubic yards of stone or stone and brush.	Cubic yards of gravel excavation.	Remarks.
11 miles.....	White's Ripple and vicinity.	2,700	2,500	
85 miles.....	Twin islands.....	1,650		
108 miles.....	Captina island.....	550	500	
112 miles.....	Fish Creek island....	400		
183 miles.....	Blennerhassett's island	1,000		
214 miles.....	Buffington island....	3,000		

As soon as the department sanctions it, the above quantities will be advertised for letting, so that the work can be done before the close of the season on all the old dams.

NEW WORKS.

The uncertainty respecting appropriations has delayed or prevented the commencement of works at other points, and, with the limited means likely to be appropriated, it will evidently be impossible to commence work at all places which may require it. In my last annual report a list of the principal bad points on the river was given, with approximate estimates of cost for their improvement.

The following places above Louisville are selected from the list as being the most urgently requiring improvements.

Miles from Pittsburg.	Place.	Estimated cost of improvement.	Remarks.
27 and 29	Beaver and Raccoon shoals	$20,000 00	
41	Line island	800 00	
90	Wheeling island	10,000 00	
133	Williamson's island	10,000 00	
167	Marietta island	20,000 00	
232	Letart's island	7,000 00	
255	Eight-mile island	3,000 00	
273	Raccoon island	700 00	Erection of land-marks, &c.
302	Guyandotte bar	3,500 00	
312	Burlington or Twelve-pole bar	10,000 00	
391	Manchester island	2,000 00	
426	Foot of Augusta bar	3,000 00	
459	Four-mile Creek bar	10,000 00	
488	Bosley or Medoc's bar	8,000 00	
508	Rising Sun bar	25,000 00	
534	Wassaw bar	15,000 00	
595	Grassy flats	16,000 00	
	Total cost	164,000 00	

At some of the points the cost can perhaps be made somewhat less, while at others the peculiarities of the river bottom in settling, and the accidents of the seasons, may make a small additional estimate requisite. A dam cannot be safely called finished until it has withstood one winter and had defects remedied.

The low-water business below Louisville is very important, but the works below that point, being costly, might be postponed until more means are granted. At some few places below Louisville the removal of numerous wrecks and snags will be a decided improvement, and perhaps in the Grand Chain, 40 miles above Cairo, some dangerous rocks can be removed. These are operations which can mostly be done by the snag-boats as they pass along, and it is not presumed that any additional cost for removing rocks, as at the Grand Chain, will add much to the total cost as above.

The points selected between Pittsburg and Louisville, a distance of 598 miles, are recognized as those most urgently requiring improvement. With their improvement alone a great commercial interest would be benefited. In some parts of this distance intercourse from place to place is confined altogether to the river, even in the worst periods of its navigation, so that the addition of a foot or more to the depth of the river would afford them margin enough to use better boats for the transportation of freight, passengers, and mail throughout the year.

Even where railroads connect places along the river, boats will carry

freight as long as they can run, the cost of transportation being so much less. A considerable and growing business during the summer and fall, in shipping coal to Louisville and Cincinnati during low water, will also be greatly benefited.

It is safe to predict that these low-water improvements alone will hereafter, in the worst coal-boat seasons, keep the price of coal from rising as it has hitherto risen, as in 1868, to exorbitant rates, when the water remained too low to boat coal from Pittsburg or Wheeling or Pomeroy.

REMOVING OBSTRUCTIONS FROM THE RIVER.

The plan adopted last year for the removal of obstructions in the river has proved successful, Captain Rodgers, of the Greenback, having at the date of last annual report been engaged about three months at the work. As he progressed down the river he succeeded in removing the snags and wrecks most dangerous to the navigation for a distance of about 325 miles, when work ceased on account of the inclemency of the weather, and the boat returned with its flats and crane-boats to Pittsburg, November 23, 1867. A secondary contract was made September 25, 1867, with Captain Rodgers, using one crane-boat, which was engaged 30 days removing the boulder rocks in the left channel of Brunot's island, which had previously rendered the navigation of that side impossible at low water. With the removal of these rocks a safe low-water channel, from 10 to 12 inches deeper than that formerly down the right side of the island, through Glass-house Ripple, was opened to commerce. This improvement was of great benefit to Pittsburg interests, and called forth unanimous satisfaction among the river men and pilots, a number of whom visited the locality and signified their approbation of the improvement in a letter published in all the papers of Pittsburg.

An estimate of cost for the continuation of the plan through another season adopted for removing obstructions, was made in my last annual report applicable to one steamer and one crane-boat for each contract. It appearing to be advisable to employ two crane-boats, and double crews with each of the steamers, an arrangement, by the permission of the department, was made, so that this year there will be two crane-boats and crews instead of one with each of the steamers.

In May, 1868, advertisements for proposals for removing obstructions were published, the first for one steamer and two crane-boats, four flats, and the necessary fixtures, and the second for two additional steamers, crane-boats, &c., as authorized by the department.

Captain John Rodgers was awarded the first contract, his price being $153 for each working day, and began operations a few days afterwards, proceeding down the river, with instructions to take out any new snags or wrecks which had come in. The regular district assigned him on the river is from Ironton, Ohio, where he left off, to Cincinnati; should he be able to work later, after reaching Cincinnati, he has orders to go below the lower parties and continue operations.

The two additional contracts were made June 25, 1868, with James Routh, of the steamer Petrolia, at $153 per full working day, and C. M. Cole and T. W. Spencer, with steamer Zebra, at $148 per full working day; each of these steamers being provided with two crane-boats, four flats, and the necessary fixtures for removing snags and wrecks, the same as Captain Rodgers.

It is expected that the Zebra, Captain Spencer, will begin operations about the 18th of July at Cincinnati, to continue to Evansville, a distance of about 330 miles. The Petrolia is now on her way to Evansville to

begin operations on her district, extending thence to Cairo, a distance of 200 miles.

In charge of the Greenback we have Captain John Shouse, United States inspector, who conducted these operations with care and ability last year. The inspector with the Zebra will be Captain B. D. Caffery, and with the Petrolia, Captain David M. Dryden, Louisville Falls pilot; all of these men are well-known pilots, possessed of energy and integrity, and well qualified for the duties assigned to them.

Although the operations of removing obstructions have begun later than last year, it is hoped that, with the additional crane-boats and double crews, and a favorable season, all the wrecks, trees, and snags known to be dangerous to the navigation of the Ohio will be taken out before the winter sets in.

I might say, in conclusion, in regard to the number of snags, &c., that the inspectors and engineering parties have from time to time been informed of others in addition to those included in a special report to the department, the removal of which will appear in the reports from the wrecking steamers.

Very respectfully, your obedient servant,

W. MILNOR ROBERTS,
U. S. Civil Engineer in charge Ohio River Improvement.

Major General A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

APPENDIX M.

UNITED STATES ENGINEER OFFICE,
Baltimore, Maryland, September 12, 1868.

GENERAL: In obedience to circular from headquarters, corps of engineers, dated June 10, 1868, I have the honor to make the following report of operations on the river improvements under my charge for the year ending June 30, 1868:

PATAPSCO RIVER IMPROVEMENT.

The necessary repairs of dredges, scows, and tug, referred to in last report as being in progress, were found to be much more extensive and costly than anticipated.

They were, however, completed about the middle of July; and three dredges, with nine scows, and one tug, commenced operations at upper end of "new cut," south from Seven Foot Knoll. Operations were vigorously prosecuted until November 1, when a severe gale, doing some injury to the dredges, caused their removal from this exposed part of the channel to a more secure position near the upper end of the old Brewerton channel, in the vicinity of Fort Carroll, where they continued operations until December 15, when the season compelled a cessation, and the property was moored in winter quarters in the inner harbor of Baltimore.

The ensuing spring, after some repairing and refitting, operations were resumed, June 15th, by the same force, in the "new cut" below Seven Foot Knoll, where they have since been continued.

The general result of the last year's operations has been the excavation of a channel from the Brewerton channel southward, past the Belvidere shoal, having a general available width of 500 feet, with a depth of 22 feet at low water, for a length of five miles.

Owing to the prevalence of hard oyster-beds on this route, it was deemed advisable to increase the width of the channel as above, through all such parts, from 200 to 500 feet.

Though it will require another season to complete the dredging, it is believed that this route will be available for use during the present working season.

The result of this season's operations encourages the belief that this alteration of the direction of the dredged channel, as proposed by Brevet Lieutenant Colonel Craighill, major of engineers, will prove a complete success, both in saving distance and permanency in depth, as the current which crossed the old route at a very obtuse angle now passes down in a direction coincident with the longitudinal axis of this channel.

In relation to the information called for by circular of June 10, 1868, paragraph 2, I have to report as follows:

1. No surveys have been made since last annual report.
2. About $175,000 will be required to complete the work.
3. About $125,000 can be profitably expended during the next fiscal year.
4. Work is located in the collection district of Baltimore.
5. The work extends from Fort McHenry past Fort Carroll, Seven Foot Knoll light, and Bodkin light.
6. Revenue collected during the year amounted to $5,900,000.
7. Commerce benefited consists of steam and sailing packets to Liverpool, Bremen, Hamburg, Havana, New Orleans, Boston, and New York, with large sailing vessels coastwise, and lumber and coal trade.
8. The following proposals have been received:

For repairs of machinery.

	Hazlehurst & Co.	Jno. Wells & Sons.	W. F. Shaw & Co.	E. J. Codd & Co.
MATERIAL.				
	Cents.	*Cents.*	*Cents.*	*Cents.*
Boiler iron.....per pound..	8	8	8	7½
Boiler rivets.....do.....	8	8	10	9
Wrought iron.....do.....	6	5½	6	7
Hammered iron.....do.....	6	6	10	9
Steel.....do.....	15	30	30	25
Iron castings.....do.....	4½	4½	3½	5
Brass castings.....do.....	25	30	30	32
Composition castings.....do.....	25	30	30	32
Sheet copper.....do.....	35	40	38	35
3-inch wrought boiler tubes.....per foot....	45	50	50	50
LABOR.				
Boiler makers.....per hour..	29	30	28	30
Forging and forge.....do.....	70	60	75	75
Drilling and drills.....do.....	40	50	50	50
Boring and tools.....do.....	70	50	50	60
Planing tools.....do.....	50	50	60	60
Turning tools.....do.....	50	50	60	60
Carpenter work.....do.....	32	30	35	30
Pattern makers.....do.....	18	20	20	20
Fitters.....do.....	30	30	30	30
Machinists.....do.....	35	40	35	35

Proposals for repairs of wood-work.

	J. H. Smith & Co.	White, Sinclair & Kemp.	Wilmer &
MATERIAL.			
Select white oak plank, per foot, board measure	$0 06	$0 05	1
Select white oak timber, per cubic foot	48	60	
Select North Carolina timber, per cubic foot	48	60	
Select North Carolina plank, per foot, board measure	05	05	
Hand-made wrought-iron spikes, per pound	10	09¼	
Machine-made wrought-iron spikes, per pound	09	08¼	
Bolt iron, per pound	07	05	
Navy oakum, per pound	11	09	
North Carolina pitch, per gallon	30	25	
Gas tar, per gallon	20	20	
Ship-smith iron, per pound	08	05	
LABOR.			
Hauling on railway, per job—dredge	30	20	
Hauling on railway, per job—scow	10 00	10 00	
Hauling on railway, per job—tug	20 00	12 00	
Use of ways, per day—dredge	17 00	10 00	
Use of ways, per day—scow	5 00	5 00	
Use of ways, per day—tug	10 00	7 00	
Ship carpenters, per hour	35	35	
Ship smiths, per hour	27½	30	
Ship calkers, per hour	35	30	
Ship scrapers, per hour	30	30	
Ship laborers, per hour	25	20	

Proposals for miscellaneous supplies.

Items.	J. G. Ramsay & Co.	Jas. Turner & Co.	R. S. Holmes & Sons.	Loane &
Brooms, corn ..... per dozen..	$4 00	$3 50	$4 00	
Brooms, hickory ..... do.....	3 50	3 25	3 25	
Brushes, paint, 0000 ..... each..	30 cts. to $1 75 dz.	18 00	25 cts. to 1 50	
Brushes, paint, 00000 ..... each..				
Brushes, paint, 000000 ..... each..				
Brushes, swab ..... each..	Junk, 12	p. dz., 5 50	40	25
Cotton waste ..... per pound..	30	20	19	
Coal-oil grease ..... per gallon..	15	20	12	
Emery paper ..... per quire..	50	24	50	
Emery cloth ..... do.....	2 25	1 50	1 60	
Files, 4½-inch ..... per dozen..	20 cts. to 1 50	8 00	11 50	
Files, 5-inch ..... do.....				
Files, 14-inch ..... do.....				
Lamp wick ..... per pound..	70	75	60	
Lampblack ..... do.....	15	15	25	
Leather bellows ..... do.....	85		50 to 75	
Leather bellows ..... per side..		5 50		
Leather rigging ..... do.....		5 50		
Leather rigging ..... per pound..	85		50 to 75	
Lead, white ..... do.....	15	16	14	
Lead, black ..... do.....	11	15	15	

Proposals for miscellaneous supplies, &c.—Continued.

Items.	J. G. Ramsay & Co	Jas. Turner & Co.	R. S. Holmes & Sons.	Loane & Brother.
red.....per pound..	$0 15	$0 16	$0 14	$0 12½
a rope .....do.....	23	24	23	23
ne.....do.....	26	28	28	25
ies.....per gross..	3 00	2 50	2 50	2 30
ard.....per gallon..	1 60	1 30	1 25	1 30
nseed, (boiled).....do.....	1 58	1 40	1 28	1 30
oal.....do.....	63	55	45	50
ing, gum.....per pound..	1 25	80 cts. to $1	98	85
ng, hemp.....do.....	35	25	29	35
ng, soapstone.....do.....	80	60	60	65
.....do.....	09	08	06½	6
, (various kinds).....do.....	25 to 60	30 to 75	25 to 50	25
ie.....do.....	21	23	22	21
a line.....do.....	21	23	22	25
s turpentine.....per gallon..	80	23	80	75
.....per pound..	10	10 to 12	10	10
r .....do.....	15	15	13½	15

Proposals for coal.

Hankey, $4 90 per ton, delivered.

9th and 10th.—*Contract for repairs of machinery.*

azlehurst & Co., prices as per abstract of proposals.

Contract for repairs of wood-work.

hite, Sinclair & Kemp, prices as per abstract of proposals.

Contract for miscellaneous supplies.

ane & Brother, prices as per abstract of proposals.

Contract for coal.

Hankey, $4 90 per ton of 2,240 pounds.

—Amount expended during the year ending June 30, 68.....		$71,017 16
unt available July 1, 1868,.....	$3,982 84	
unt of appropriation of July 25, 1868, apportioned to this work by engineer department, ly 30, 1868.....	17,000 00	
		20,982 84
unt to be expended during the year ending June 30, 1869		20,982 84
opriation required for the year ending June 30, 1870..		125,000 00

IMPROVEMENT OF THE SUSQUEHANNA RIVER.

Since the date of last report contracts have been let for all the labor and material required to complete this improvement, so far as the present appropriation will admit.

Operations were commenced on the construction of the three cribs in September, 1867. Owing to unavoidable delay in procuring some of the long piles required, these were not completed in time to admit of being filled entirely with stone, and in consequence two of them were so much injured by ice during the last winter as to necessitate their reconstruction this spring.

Work was carried on also during the fall and winter on the construction of the rafts, and they will now soon be ready to be put in place. It is hoped that this improvement will be in working order by November 1st, at the latest. During the last season, to relieve the commerce of the port, it was found essential to remove some accumulations of sand, formed by ice, at the lower end of the old dredged channel, and it was effectually done under contract, by the removal of about 30,000 yards of material, giving a depth of eight feet at low water, through the shoal, about two miles long.

The general effect of a boom for the collection of logs, constructed last fall very near the line selected for the "deflector," to improve this river, renders the result of this method of increasing the depth of water in the old channel almost a certainty; and in view of this fact it is deemed very desirable that a permanent structure be substituted for the intended temporary one, which will obviate the necessity of any further expenditures for this work. An estimate for such a structure will be found in its appropriate place in this report.

In reply to circular of June 10, 1868, I would report as follows:

1. No surveys have been required since last report.
2. Amount required to complete the work permanently, $50,000.
3. Fifty thousand dollars can be profitably expended during the next fiscal year.
4. The work is in the collection district of Baltimore.
5. The work is located between Point Concord light and Donohue's Battery light.
6. The amount of revenue collected at the nearest port of entry, Baltimore, during the last fiscal year, was $5,900,000.
7. The commerce benefited by this improvement consists of all trade coming through Susquehanna and Tide-water canal, and the whole lumber trade of the upper Susquehanna.
8. The following proposals have been received for this work:

Proposals for material—(wood.)

	J. A. Davis.
16-inch yellow pine piles, 50 feet long, per foot	$0 22
16-inch yellow pine piles, 30 feet long, per foot	20
White pine timber, per 1,000 feet, (board measure,) for cribs	32 00
White pine timber, per cubic foot, for deflector	25
Locust treenails, 24 inches long, per 1,000	40 00
Oak treenails, 24 inches long, per 1,000	25 00
3-inch white pine plank, per 1,000 feet, (board measure)	30 00

Proposals for iron.

	Sykes & Co.	P. J. Field.	J. A. Davis.
	Cts.	*Cts.*	*Cts.*
Connecting links.....per pound..	10	11	11
Spikes.....do.....	10	08¼	09

Proposals for stone.

J. J. Heckart, $1 88 per cubic yard.

Proposals for labor.

	J. A. J. Rutter.	J. A. Davis.
For framing and constructing cribs.....	$1,350	$385 21
For framing and constructing deflector, per 1,000 feet, (b. m.).....	.....	10 00

9th and 10th.—*Contract for timber for cribs.*

J. A. Davis, prices as per schedule.

Contract for building cribs.

J. A. Davis, price as per schedule.

Contract for iron work.

Sykes, Kelly & Co., prices as per schedule.

Contract for timber for deflector.

J. A. Davis, prices as per schedule.

Contract for framing deflector.

J. A. Davis, prices as per schedule.

Contract for rubble stone.

J. J. Heckart, price as per schedule.

11th.—Amount received and expended for the year ending June 30, 1868..... $22,899 05
Amount available July 1, 1868..... 13,500 95

Amount to be expended during the year ending June 30, 1869	$13,500 95
Amount required for the year ending June 30, 1870	50,000 00

It is proper for me to state that the above-named improvements of the Patapsco and Susquehanna rivers were under the charge of Brevet Lieutenant Colonel W. G. Craighill, major corps of engineers, until September 24, 1867, when by the operation of Orders No. 84, headquarters corps of engineers, September 11, 1857, he was relieved by Brevet Major General J. G. Parke, major corps of engineers, who remained in charge till June 1, 1868, when agreeably to Special Orders No. 66, headquarters corps of engineers, May 25, 1868, I took charge.

I am, general, very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers and Brevet Brigadier General U. S. Army.

Brevet Major General A. A. HUMPHREYS,
Commanding Corps of Engineers, Washington, D. C.

APPENDIX N.

Progress made in the completion and repairs of the Delaware breakwater, Delaware, during the year ending June 30, 1868.

From the 1st of July, 1867, to the 2d of November, work was carried on under the contracts for furnishing material and labor which were in force the preceding season.

Owing to faulty and insufficient machinery, and want of proper management on the part of the contractor for labor in receiving and putting stones in position, but little progress was made; vessels accumulated; there was great and aggravating detention in awaiting their turn for discharge; the contractors for stone could, with great difficulty, procure vessels to take it, and were unable to send more than three-fifths of the quantity which otherwise should have been received. It became necessary to extend their time of fulfillment of contract to the present season.

The experience of the past year having clearly demonstrated the impracticability of receiving and putting the stone at this work in position by contract without great delay and pecuniary loss to the United States, at the commencement of the present season machinery was procured and arrangements for the necessary labor were made. On account of the loss incurred by vessels last year, it was difficult to procure any for operations this year, and no stone was consequently received until the 8th of June and but little until the close of the fiscal year. As was anticipated, the attempt to carry on such a work by separate contracts for each class of labor or material only resulted in general delay, loss, and unmitigated confusion.

During this year the gap in the breakwater proper, some 210 feet in length, was closed, and 228 running feet of old work replaced and raised to the proper height. About 2,216 running feet of the superstructure have now been put in shape, and some 350 feet in length, at the last end, are yet to be raised about seven feet in order to complete the work on its present base, which will require some 7,000 tons of stone.

Commencing at the portion of the ice-breaker near mid-length, which has been completed, and working to the east, about 87 running feet of

the superstructure have also been brought to the full height. Between the west end, which iscompleted, and the middle is a gap of about 475 feet in length to be raised about three feet, and from where work is now carried on, going east for 326 feet, the work is about five feet below the proper level, and then for 195 feet about one foot six inches too low. About 365 feet in length may be regarded as finished, and about 996 feet still to be brought to proper level. It is estimated this will require some 8,500 tons of stone to be furnished in addition to what old stone may be relaid.

To protect the ends, by in part filling holes which have formed, may require some 16,000 tons of small stones.

During the year, 8,100 tons of stone have been received from vessels and put in position on the works, and 1,129 tons of old stone removed and relaid.

Expenditures for the year ending June 30, 1868.

Stone paid for, 7,671 tons, at $4 73	$36,283 83
Labor paid for on 8,275 tons in place, at $1 22	10,095 50
Machinery, cranes, engines, blocks, spars, ropes, &c	7,213 54
Services of mechanics and laborers	400 21
Contingencies, inspectors, office, stationery, &c	4,696 92
Total for year ending June 30, 1868	58,690 00
Expended during year ending June 30, 1867	4,253 35
Total expended under late appropriations to June 30, 1868	62,943 35
In hands of agent July 1, 1868	9,856 65
In treasury July 1, 1868	144,603 70
Balance of appropriation July 1, 1868	154,460 35
Amount due contractors for stone delivered but retained on part payment to July 1, 1868	4,458 00
Total available for year ending June 30, 1869	150,002 35

It is believed this sum will complete the works on their present basis. Amount that can probably be profitably expended during the year ending June 30, 1869, $70,000.

The breakwater is located in the collection district of Delaware. The nearest port of entry is Wilmington. There is a light-house upon the breakwater, and others on Cape Henlopen. Fort Delaware is the nearest fort. The amount of revenue collected at Wilmington during the fiscal year ending June 30, 1868, is reported as being $49,797 51.

The following table, compiled from the very imperfect records kept from time to time by different persons, gives some idea of the benefit to general commerce and navigation derived from this work in its incomplete completion, since raised sufficiently above the surface of the water to afford any shelter to vessels seeking a refuge from storms and the sea:

Classes and numbers of vessels sheltered by the breakwater.

Years.	Ships.	Barks.	Brigs.	Schooners.	Sloops.	Pilot boats.	Steamers.	Total.	Remarks.
1833..	22	.....	178	372	167	127	.....	866	From September 1, inclusive.
1834..	48	.....	315	667	303	411	.....	1,744	July 1 to Oct. 17 not recorded.
1835..	133	.....	569	1,719	461	641	.....	3,526	
1836..	301	.....	1,027	2,719	620	767	.....	5,434	
1837..	227	.....	478	2,777	629	732	.....	4,843	
1838..	165	.....	732	3,191	765	685	.....	5,538	
1839..	165	.....	504	3,561	734	697	.....	5,661	
1840..	172	.....	279	1,909	308	371	.....	3,039	To June 3, inclusive.
1841..	111	.....	902	3,916	590	483	.....	6,002	From May 1.
1842..	107	.....	1,060	5,335	802	794	.....	8,098	
1843..	103	.....	841	4,981	1,167	792	.....	7,884	
1844..	231	.....	969	5,797	854	744	.....	8,595	
1845..	265	.....	1,042	5,446	597	776	.....	8,126	
1846..	258	.....	1,625	6,711	614	781	.....	9,989	
1847..	342	.....	1,937	7,742	358	874	.....	11,253	
1848..	340	.....	1,457	6,037	374	918	.....	9,126	
1849..	329	.....	804	3,261	168	553	.....	5,115	
1854..	35	247	1,085	5,098	90	.....	114	6,669	From April 1, inclusive.
1855..	65	240	855	6,808	128	.....	243	8,339	
1856..	116	425	1,062	6,125	256	.....	286	8,270	
1857..	79	331	981	5,348	218	.....	220	7,177	
1858..	6	34	78	1,030	174	.....	38	1,360	To March 31, inclusive.
1862..	55	239	879	8,087	253	.....	246	9,759	From February 1, inclusive.
1863..	231	345	1,040	7,092	251	.....	347	9,306	
1864..	231	308	1,155	7,781	189	.....	299	9,963	
1865..	274	378	1,179	6,056	209	.....	372	8,468	
1866..	28	227	694	6,747	299	.....	316	8,311	
1867..	113	290	825	8,000	307	.....	279	9,814	
1868..	37	294	528	4,227	119	.....	229	5,434	To June 30, inclusive.
	4,598	3,358	25,080	138,540	12,004	11,149	2,989	197,709	

From these figures, if correct, it appears that during the 29 years stated, for each recorded day an average number of 21 vessels have been at anchor behind the breakwater.

An abstract of proposals for labor for putting stone in position at this work during the present year is transmitted herewith.

No contracts have been entered into since the last annual report.

It is supposed that for purposes of repair, at an interval of about 15 years, an appropriation of $22,500 may be required for the work.

Respectfully submitted.

C. SEAFORTH STEWART,
Lieut. Colonel of Engineers.

Abstract of proposals for labor for Delaware breakwater.

No.	Name of bidder.	Rate per ton of 2,240 lbs.
1	Samuel Strong	$1 98
2	A. M. Maynard and J. R. Duter	1 75
3	Charles Joseph Kennedy	1 75
4	Milo W. Locke	1 40
5	James E. Neall	*1 56, 1 55
6	Hiram Bitting, (not in duplicate)	2 24

* James E Neall's proposals; one copy had the rate at $1 56 and the other copy $1 55.

C. SEAFORTH STEWART.
Lieut. Colonel of Engineers.

PHILADELPHIA, PA., *August* 14, 1868.

N 1.

Report of progress made in improving harbor at Marcus Hook, Pennsylvania, during the year ending June 30, 1868.

Contracts for iron, timber, and labor, for repairs of old piers, wharves, and landings at Marcus Hook, having been entered into on the 29th of June, 1867, with William H. Rotan, and approved, work under them was begun early in July following. It was found necessary to remove all the old wood-work and rebuild. The obstructions caused by the ruins of old pier-heads off the southern wharf were in part taken up, piles driven, cut off and capped at low water, and a platform built, on which a new pier, about 31 by 41 feet, was constructed. The corresponding inner wharf was torn down and replaced, and a bridge of some 54 feet span built to connect it with the pier, making for the southern United States pier about 2,865 feet vertical face of pier work, with all the necessary ties, drag-logs, fenders, moving posts, corner plating, &c. The outer portion of the northern pier was cut down to low water, piles driven, cut off, capped, and platform built for foundation for the greater part of this pier, and the whole pier and inner wharf removed and reconstructed, and a bridge of about 31 feet span built between pier head and wharf. In the upper United States pier about 3,041 feet vertical face of pier work were constructed, with ties, drag-logs, &c., complete. These repairs have required in all 17,091 feet face of pine and hemlock wharf timber, 7,848 lineal feet of hemlock round timber, 9,485 feet, board measure, of oak fenders, 48,959 feet, board measure, of pine bridge timbers, caps, &c., and 24,917 pounds of iron work. The piers and wharves have all been filled in, and are in excellent order. The repairs undertaken have all been made in a very satisfactory manner, though requiring a much longer time than was anticipated.

Expenditures on repairs under contracts with William H. Rotan.

7,417 feet 7 inches face hemlock wharf timber, at 14 cts	$1,038 46	
7,848 feet lineal, hemlock round timber, at 7 cts	549 36	
9,613 feet 8 inches face white pine, wharf and cap logs, at 30 *cts*	2,902 09	

48,959 feet 4 inches, board measure, white pine bridge timber and moving posts, at 4 cts.	$1,958 37		
9,485 feet board measure, oak fenders, at 5½ cts.	521 67		
		$6,969	95
13,636 pounds wrought-iron wharf bolts, at 7 cts.	954 52		
3,107 pounds wrought-iron screw bolts, at 14 cts.	434 98		
8,174 pounds wrought-iron corner plates, &c., at 10 cts	817 40		
		2,206	90
Labor on timber, &c.		4,027	09
Contingent expenses		663	72
Expenditures on repairs during year ending June 30, 1868		13,867	61
Expended advertising, &c., during year ending June 30, 1867		334	27
Total cost of repairs to June 30, 1868		14,201	88

For the additional piers proposed for the improvement of the harbor separate contracts were entered into, on the 13th of July, for the timber and the labor on the crib-work, with A. P. Eyre. On the 15th of July another contract was made with I. R. Grant, for the iron-work required; on the 18th of the same month one with John C. Leiper, for all the stone necessary; and one on the 20th of August, 1867, with Robert Crane and John Keaveny, for the labor in laying the stone superstructure of the piers. These contracts having been approved, work on the cribs was begun early in July, 1867.

All the suitable timber, it seems, had been bought up by interested persons, apparently to cause the contractor to give up his contract or pay them a heavy price for the timber. The dryness of the latter part of the summer prevented the usual supply from reaching the market, so that from these causes and bad management but little work was done during the season, and winter closed in before the first crib was ready. It grounded, and has not yet been put in place. The time of the contractor having been extended, he resumed operations this spring with considerable vigor, and has built, sunk in position, and nearly filled two cribs, and nearly completed the fourth for sinking. Those in place are settling slowly. The other contractors, owing to the delay in preliminary operations, have been awaiting progress. Some 70,173 feet face of hemlock wharf timber and 39,314 pounds wharf bolts have been procured for the cribs, and 612 perches of stone filling. Considerable stone for the superstructure has been quarried.

Expenditures on cribs under contract with A. P. Eyre, I. R. Grant, and John C. Leiper.

56,138 feet face hemlock wharf timber, at 13¼ cts	$7,438 28
28,058 feet face of labor on cribs, at 5 cts	1,402 90
31,448 pounds wrought-iron wharf bolts, at 6½ cts	2,044 12
488 perches, of 25 feet, of stone filling, at $1 40	683 20
Contingencies	1,010 39
Expended during fiscal year ending June 30, 1868	12,578 89
Contingencies during fiscal year ending June 30, 1867	503 71
Total expenditure on new piers to June 30, 1868	13,082 60

In hands of agent July 1, 1867		$4,212 02
Received from treasury during fiscal year ending June 30, 1868		25,000 00
In hands of agent during fiscal year ending June 30, 1868.		29,212 02
Expended during fiscal year ending June 30, 1868, in repairs	$13,867 61	
Expended during fiscal year ending June 30, 1868, on new piers	12,578 89	
Total expenditures for fiscal year ending June 30, 1868..		26,446 50
To be accounted for		2,765 52
Deposited in February by agent, during year ending June 30, 1868		2,000 00
In hands of agent June 30, 1868		765 52
In treasury June 30, 1868		70,950 00
Amount available for year ending June 30, 1869		71,715 52
Total expenditures under appropriations, &c., to June 30, 1868,		27,284 48
Total amount appropriated to June 30, 1868		99,000 00
Probable amount required for the entire and permanent completion of the work begun		71,715 52
Amount that can probably be profitably expended during the fiscal year ending June 30, 1869		71,715 52

It is believed this amount will complete the works on the plan adopted, and nothing is asked for the year ending June 30, 1870.

Marcus Hook is in the collection district of Philadelphia. The nearest port of entry, light-house, and fort, are respectively Wilmington, Delaware, Christiana light, and Fort Mifflin. The amount of revenue collected at Wilmington during the past fiscal year is $49,797 51. This harbor, when completed, will be a convenient one for refuge from running ice during the winter season, and may lead to the establishment of a coal depot at this point, or otherwise increase local commerce.

Abstracts of proposals, with names of bidders, of contracts with names of contractors, and of contracts for each class of materials or labor, for this work, have already been forwarded with my letter of September 11, 1867, to the Chief of Engineers United States army. It is probable that at intervals of about ten years the sum of $7,000 may be required for repairs and preservation of this harbor.

Respectfully submitted.

C. SEAFORTH STEWART,
Lieutenant Colonel of Engineers.

N 2.

Report of progress made in improving harbor at Chester, Pennsylvania, during the year ending June 30, 1868.

In accordance with the act of Congress making the appropriation for this harbor, three separate contracts for furnishing the requisite timber, iron, and labor, respectively, for the repairs of the United States piers, bridges, and wharves at Chester, were entered into on the 25th and 26th of July, 1867, before approval of these contracts by proper authority, and notification thereof to the contractors. Work was begun early in August, and carried on satisfactorily to entire completion.

On the 12th of October, of the same year, proposals were invited, by advertisement, for the stone for repairs and completion of the walls of the causeways leading to the piers, for labor in laying this stone, and for the materials requisite for filling in the roadways. Separate contracts for each of these items, in compliance with the law, were made on the 25th and 28th of October, 1867. They were duly approved, and work begun under them.

The contractor for stone, upon whose movements those of the other two were wholly dependent, failed to furnish it as rapidly as was necessary; winter closed in suddenly, before all had been sent. The others were then forced, through his neglect, to modify their plan, to break up the organization of their forces, were put to increased expense, and were rendered unable to fulfill their contracts as they could and would have done to the letter, had it not been for his delay. In justice to them it became necessary to grant an extension of time, so that the work, instead of being promptly finished, as it should have been by the 1st of January, 1868, was not until the 18th of June, or nearly six months later, owing to the unfortunate provisions of the law, thereby adding greatly to the contingent expenses incurred by the United States.

In making the repairs, about 5,400 feet face measurement of the wharves and piers have been replaced with the necessary ties, backing, fenders, moving posts, and corner plating. The upper bridges have been repaired, and at the lower pier a new bridge built, some 52 feet span in the clear, with a roadway about 17 feet in width, calculated for heavy teams. The walls or causeway to lower pier bordering Chester creek have been in great measure rebuilt, wholly repaired, and raised throughout its length of upwards of 612 feet at least one foot in height, so that they are now entirely above high water except in extraordinary high tide. The space between the walls has been filled in throughout with good road materials, and the piers and wharves properly filled in. The wall of upper causeway has also been repaired, and the roadway likewise put in good order. All the repairs contemplated have been completed. Besides the materials on hand, there have been procured for these repairs about 3,000 feet face of white pine wharf timber, nearly 51,000 feet, board measure, of white pine and oak timber, some 472 perches of stone, 1,617 cubic yards of filling, and 10,690 pounds of iron wall. About 856 perches of stone wall were laid in the causeway walls. The improvements contemplated having been made, the small balance on hand will probably suffice for repairs for the ensuing fiscal year.

Chester is in the collection district of Philadelphia. That city is the nearest port of entry. Fort Mifflin is the nearest fort, and Fort Mifflin light the nearest light-house. The amount received during the fiscal year ending June 30, 1868, from duties and imports at Philadelphia, is reported

as being $8,406,906 71. Being on the great river thoroughfare to Philadelphia, Chester is, during the winter season, a convenient place of refuge from running ice, and its harbor is then much used by other vessels than those directly bound to it.

Abstracts of proposals with names of bidders, of contracts with names of contractors, and of contracts for each class of materials or labor for repairs of causeway, &c., are forwarded herewith. Those relating to repairs of piers, wharves, &c., at Chester, have already been forwarded to headquarters corps of engineers with my letter of September 11, 1867, and been published in the report for the year 1867.

Statement of cash received and expended.

In treasury and available July 1, 1867		$11,000 00
Liabilities incurred before July 1, 1867	$296 58	
Expended for timber during year ending June 30, 1868	2,737 72	
Expended for iron work during year ending June 30, 1868	884 86	
Expended for labor and repairs to piers during year ending June 30, 1868	971 58	
Expended for stone for walls of causeway during year ending June 30, 1868	1,743 66	
Expended for labor on walls of causeway during year ending June 30, 1868	1,498 49	
Expended for filling roadway during year ending June 30, 1868	946 22	
Expended for advertising repairs during year ending June 30, 1868	204 99	
Expended for contingent services, &c., during year ending June 30, 1868	1,363 04	
Expended from appropriation to June 30, 1868.	10,647 14	10,647 14
Received from treasury during year ending June 30, 1868	10,500 00	
Due from United States June 30, 1868	147 14	
In treasury June 30, 1868	500 00	
Available for year ending June 30, 1869		352 86
Probable expenditures to June 30, 1869		352 86
On hand July 1, 1865		000 00

Nothing required for year ending June 30, 1869. In the course of 10 years probably $7,000 may be required for renewal of upper portions of piers, wharves, bridges, and general repairs.

Respectfully submitted.

C. SEAFORTH STEWART,
Lieutenant Colonel of Engineers.

Abstract of proposals for repairs of causeway at Chester, Pennsylvania.

No.	Name of bidder.	Stone.		Filling.				Labor.
		Foundation, per perch.	Coping, per cubic foot.	Quarry dirt, per cubic yard.	Earth, per cubic yard.	Mud, per cubic yard.	Gravel, per cubic yard.	Per perch.
1	P. McAdams	$3 50	$0 50	$1 00	$0 50	$0 50	$0 75	$4 00
2	Jas. E. Neall	2 49	49	.....	.....	.....	.....	.....
3	Alex. Givin	.....	.....	98	98	98	98	*2 98
4	A. O. & J. O. Deshong, jr.	3 75	75	1 15	1 00	85	1 25	.....
5	McLaughlin & Crellis	.....	.....	.....	.....	.....	.....	3 00
6	Hiram Bitting	.....	.....	.....	.....	.....	.....	1 75

*Per cubic yard.

C. SEAFORTH STEWART,
Lieutenant Colonel of Engineers.

PHILADELPHIA, PENNSYLVANIA,
July 22, 1868.

Abstract of contracts for repairs of causeway at Chester, Pennsylvania.

Name of contractor.	For what purpose.
Patrick McAdams	Filling.
James E. Neall	Stone.
Hiram Bitting	Labor.

C. SEAFORTH STEWART,
Lieutenant Colonel of Engineers.

PHILADELPHIA, PENNSYLVANIA,
July 22, 1868.

Abstract of contracts for each class of material, and of labor for repairs of causeway at Chester, Pennsylvania.

Contractor.	Stone.		Filling.		Labor.
	Foundation, per perch.	Coping, per cubic yard.	Earth, per cubic yard.	Gravel, per cubic yard.	Per perch.
James E. Neall	$2 49	$0 49	.....	.....	.....
Patrick McAdams	.....	.....	$0 50	$0 75	.....
Hiram Bitting	.....	.....	.....	.....	$1 75

C. SEAFORTH STEWART,
Lieutenant Colonel of Engineers.

PHILADELPHIA, PENNSYLVANIA,
July 22, 1868.

N 3.

Report of progress made in survey of Reedy island, Delaware river, during the year ending June 30, 1868.

This survey, in progress by a party under charge of Assistant R. M. Bache, United States Coast Survey, at the close of the year ending June 30, 1867, was continued until the 10th of July of the same year, when the field-work was completed. The maps having been drawn during the winter season, a tracing thereof, with a detailed report, in accordance with the requirements of sections two and four of an act making appropriations for the repairs, preservation, and completion of certain public works, &c., approved March 2, 1867, was forwarded to headquarters corps of engineers, Washington, D. C., with my letter of March 25, 1868, to which report reference is respectfully made.

Respectfully submitted.

C. SEAFORTH STEWART,
Lieutenant Colonel of Engineers.

N 4.

Report of the progress made at Liston's Tree Point, Delaware, during the year ending June 30, 1868.

This survey was commenced by a party under charge of Assistant R. M. Bache, United States Coast Survey, on the 11th of July, 1867, and the field-work completed on the 24th of September, 1867. The survey began at a point some 500 yards below Liston's Tree Point, and ended about two miles above it. The map of the survey having been finished during the winter season, a tracing of it, and a report in detail, giving the data required by the act of Congress approved March 2, 1867, under which the survey was made, were transmitted by me under date of March 31, 1868, to headquarters corps of engineers, Washington, D. C., to which report reference is now respectfully made.

Respectfully submitted.

C. SEAFORTH STEWART,
Lieutenant Colonel of Engineers.

N 5.

Survey of Reedy island, Delaware river.

This survey was begun on the 1st of May, 1867, by a party in charge of Assistant R. M. Bache, United States Coast Survey. Owing to the unusual amount of rainy, stormy weather for the season, progress in the field-work was much interfered with, and it was not completed until the 10th of July.

An area, about three miles in length by one in breadth, including the Delaware shore in the vicinity of Fort Penn, the whole of Reedy island, and the belt of the river adjacent thereto for a half mile in width, is embraced within the limits of the survey.

The details of the shore, the horizontal curves of the bed of the river taken at vertical distances of six feet, commencing with the low-water line, the position of the piers of the harbor constructed in 1853, and the proposed changes, are shown upon the tracing transmitted herewith.

From a special examination of the existing pile piers, made November 8, 1867, it was ascertained the material of which they were built was in general in a state of good preservation from low-water mark to a point some two feet or more above that level. The upper portions, in places, were damaged and decayed. To make the piers of use, it will be necessary to cut them down to low-water level and build up from that point with usual pier-work.

The most exposed corners of the two outer piers of the lower line have been driven in or carried away. The two piers of the upper line, never having been completed and braced as was intended, have been more severely damaged by the ice than the other piers; a number of piles in each have been broken off and thrown out of position. By replacing the piles and rebuilding, as above stated, all can be put in good shape.

As shown by the survey, the inner portion of the harbor has been filled in with mud, probably in some places to a depth of 10 feet; the outer portion has been deepened some six feet and upwards. According to report, extensive changes in the bed of the river above Reedy island and in its vicinity are going on, which may or may not prove detrimental to the harbor. Time alone can show what may result.

The nearness of the main channel, the depth of water that can be obtained, the ease of ingress and egress at all times, to vessels of any size going up or down stream, and the use that can be made of the piers already in position, lead me to propose an extension of the harbor, as indicated by full red lines upon the tracing.

The two new piers on the lower line to be placed at intervals of 80 feet, the exterior salient of each overlapping the interior salient of its predecessor by 20 feet. Four piers to be added to the upper line, at like intervals; the exterior salient of each being 20 feet within that of its predecessor. The axes of all piers in the thread of the current. The extreme length, at low water, of the piers to be 80 feet, the breadth 40 feet, the general construction of these timber piers being shown upon the tracing. The outlet between exterior piers will be about 343 yards, and the average breadth of harbor, to the six-foot curve of bottom, about 150 yards. To give better protection from ice during easterly storms, an intermediate pier might be placed, as indicated by a broken red line; but such a pier would at times interfere with the free ingress and egress of vessels.

The following are the estimates of the cost of survey, and for repairs and extension of the harbor.

Cost of survey.

Services of hands employed in survey, soundings, &c.....	$932 10
Expended for signals, buoys, and miscellaneous articles....	43 93
Contingencies.....	159 05
Total.....	1,135 08

Estimate of probable cost of repairs of one pier.

Oak piling, 1,000 lineal feet, at 30 cents.....	$300 00
White pine sawn, board measure, 14,940 feet, at 3½ cents....	522 90
White pine wharf timber, 1,200 feet face, at 30 cents.....	360 00
White pine tie timber, 3,300 feet, lineal, at 20 cents.....	660 00

mlock wharf timber, 2,420 feet face, at 18 cents	$435 60
mlock tie timber, 1,350 lineal feet, at 8 cents	108 00
hite oak fenders, board measure, 2,550 feet, at 5 cents	127 50
lvanized plating, screws, bolts, &c., 3,665 lbs., at 13 cts.	476 45
lvanized wharf bolts, 9,750 lbs., at 10 cents	975 00
ne filling, 200 perches, at $3	600 00
id filling, 450 yards, cubic, at 50 cents	225 00
bor on 14,940 feet, board measure, sawn timber, at 1½ cents,	224 10
bor on 3,620 feet face, wharf timber, at 7 cents	253 40
bor on 4,650 lineal feet, tie timber, at 7 cents	325 50
bor on 12 large fenders, at $3	36 00
bor on 16 common fenders, at $1 50	24 00
bor driving 20 piles, at $5	100 00
ntingencies	1,246 55
Total for repairs of one pier	7,000 00
For seven piers—total	49,000 00

timate of probable cost of a new pier, to be 80 feet long by 40 feet wide at low-water line, its top 12 feet above that level, with a batter of one inch to the foot. Total height of pier from hard bottom about 50 feet.

ONE PIER.

emlock wharf timber, 39,300 feet face, at 18 cents	$7,074 00
emlock tie timber, 2,500 lineal feet, at 8 cents	200 00
hite pine cap logs, 460 feet face, at 30 cents	138 00
hite pine wharf timber, 1,680 feet face, at 30 cents	504 00
hite pine tie timber, 2,800 lineal feet, at 20 cents	560 00
hite oak fenders, 2,800 feet, board measure, at 5 cents	140 00
lvanized wharf bolts, 29,500 lbs., at 10 cents	2,950 00
lvanized screw bolts, 785 lbs., at 13 cents	102 05
lvanized plating, 2,665 lbs., at 13 cents	346 65
bble stone, 1,350 perches, at $3	4,050 00
rth filling, 600 cubic yards, at 50 cents	300 00
bor on wharf work, 45,121 feet, at 7 cents	3,158 47
bor on heavy fenders, 18, at $3	54 00
bor on common fenders, 14, at $1 50	21 00
ntingencies	2,401 83
Total probable cost of one pier	22,000 00
Six piers would, therefore, cost	132,000 00

RECAPITULATION.

timated cost of repairs to seven old piers	$49,000 00
timated cost of six new piers	132,000 00
Total amount required	181,000 00
obable amount that can be profitably expended during he fiscal year ending June 30, 1869	90,000 00

Reedy island is in the collection district of Delaware. Wilmington, Delaware, is the nearest port of entry. Reedy island light is on the island. The amount of revenue collected at Wilmington during the fiscal year ending June 30, 1867, is stated to be $41,733 96.

Fort Delaware is the nearest fort.

The amount of commerce or navigation that will be benefited by the completion of the harbor is not known. Large vessels will only put in when compelled to by ice or stress of weather, when the services of a tug are not to be had. No reliable data for forming a satisfactory opinion upon the point is at hand.

Respectfully submitted.

C. SEAFORTH STEWART,
Lieutenant Colonel of Engineers.

N 6.

Report of survey at Liston's Free Point, Delaware, in 1867.

This survey was begun by a party under the charge of Assistant R. M. Bache, United States Coast Survey, on the 11th of July, 1867, and the field-work completed on the 24th of the following September.

The tracing from a map of the result of the survey, sent herewith, exhibits the Delaware and its shore from 500 yards below Liston's Free Point to nearly two miles above, taking in a breadth of about half a mile to the 24-feet curve of the bottom. The shore about the point is flat and marshy. The bottom of the river is reported to be of soft mud and of a gentle slope—the 6-feet curve below low-water line being at the nearest point to it, some 120 yards off; the 12-feet curve at 160, the 18-feet at 260, and the 24-feet curve at 520 yards. As seen, the deepest water approaches the shore line about opposite the best salient portion of Liston's Free Point, and as you move from this salient either up or down stream the deep water recedes rapidly from the shore. Opposite this point has therefore been selected as the location for a harbor, if one is to be constructed in this vicinity.

The general direction of the channel is northwest and southeast, and as there is quite a long reach of water above and below, the sea off the point is reported to be at times very heavy. The shore has the same general direction with the channel. It is proposed to place the protecting masses or piers of crib-work to form the harbor in two lines at the shore, 400 yards apart and normal to it, up to the 6-feet curve below low water, thence gradually approaching each other until in 21 feet water they terminate, leaving an interval of 725 feet between their extremities. Were this opening greater, as the distance to the opposite shore is 2¾ miles, during easterly blows the ice massed on this shore would be forced in large quantities directly into the harbor. The space thus protected is, for vessels of large draught, limited, and is deemed the smallest harbor that would be of any service. The area can be increased by moving the upper line some 200 yards up stream, and placing an intermediate pier on the line joining the extremities of the two lines; also by carrying the piers out, at great expense, into deeper water, and by a combination of the two methods. From the nature of the bottom, should vessels come in contact therewith at low water no damage would probably ensue. As indicated on the tracing, 21 large piers 80 feet long

by 40 feet broad at low-water line will be required, and two smaller ones 60 feet by 30 feet wide, the intervals of the larger being 75 feet.

The following, so far as known, are the items of expenditure for the survey:

Cost of survey.

Services of hands employed in soundings, &c	$1,058 85
Expended for signals, &c., and miscellaneous articles	59 46
Contingencies	158 70
Total known cost	1,277 01

Estimate of cost of one large pier.

39,300 feet face hemlock wharf timber, at 18 cents	$7,074 00
2,500 lineal feet hemlock tie timber, at 8 cents	200 00
460 feet face white pine cap logs, at 30 cents	138 00
1,680 feet face white pine wharf timber, at 30 cents	504 00
2,800 lineal feet white pine tie timber, at 20 cents	560 00
2,800 feet, board measure, white oak fenders, at 5 cents	140 00
29,500 pounds galvanized wharf-bolts, at 10 cents	2,950 00
785 pounds galvanized screw-bolts, at 13 cents	102 05
2,665 pounds galvanized plating, at 13 cents	346 65
1,350 perches rubble stone, at $3	4,050 00
600 cubic yards earth filling, at 50 cents	300 00
Labor on wharf work, 45,121 feet, at 7 cents	3,158 47
Labor on heavy fenders, 18 feet, at $3	54 00
Labor on common fenders, 14 feet, at $1 50	21 00
Contingencies	2,401 83
Total probable cost of one large pier	22,000 00
Twenty-one large piers would cost	462,000 00

Estimate of cost of one small pier.

11,836 feet face hemlock wharf timber, at 18 cents	$2,130 48
1,920 lineal feet hemlock tie timber, at 8 cents	153 60
1,630 feet face white pine cap logs and wharf timber, at 30 cents	489 00
2,000 lineal feet white pine tie timber, at 20 cents	400 00
2,800 feet, board measure, white oak fenders, at 5 cents	140 00
11,400 pounds galvanized wharf-bolts, at 10 cents	1,140 00
3,450 pounds screw bolts and plating, at 13 cents	448 50
512 perches rubble stone, at $3	1,536 00
Labor on 16,876 feet wharf work, at 7 cents	1,181 32
Labor on 18 heavy fenders, at $3	54 00
Labor on 14 common fenders, at $1 50	21 00
Contingencies	1,306 10
Total probable cost small pier	9,000 00
Two small piers would therefore cost	18,000 00

RECAPITULATION.

Twenty-one large piers at $22,000	$462,000 00
Two small piers at $9,000	18,000 00
Total cost	480,000 00
Probable amount that could be expended profitably during the fiscal year ending June 30, 1869	150,000 00

Liston's Tree point is in the collection district of Delaware. The nearest port of entry, light, and fort are respectively Wilmington, Delaware, Bombay Hook light, and Fort Delaware.

During the fiscal year ending June 30, 1867, the amount of revenue collected at Wilmington, Delaware, was $41,733 96. No data is on hand or to be obtained for estimating the amount of commerce or navigation that will be benefited by the construction of a harbor at Liston's Tree point.

Respectfully submitted.

C. SEAFORTH STEWART,
Lieutenant Colonel of Engineers.

N 7.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., April 30, 1868.

SIR: In accordance with request in letter from headquarters corps of engineers, of the 15th instant, and under special orders from the same, of the 17th instant, directing me to proceed to the vicinity of the mouth of the Metedeconk river, near the head of Barnegat bay, New Jersey, for the purpose of making an examination as to the necessity of opening an inlet on the New Jersey coast, from the Atlantic ocean to the above point, I have the honor to report that on the 23d instant I proceeded to that neighborhood.

On the following day an examination was made of that portion of the New Jersey coast just below the mouth of the Metedeconk, more particularly where those interested in procuring the opening of the inlet proposed to locate it. A tracing sent herewith giving a rough sketch, marked 1, shows the general character of the ground and the approximate width, at certain points, of the strip of the coast between the ocean and bay; also, according to information received on the spot, the intended position A B for the inlet. The sketch 2 is from the general chart of the coast, having marked on it about the location of the point A of sketch 1.

The coast here, as usual, consists of a range of sand hills, varying in size and shape, and from 10 to 25 feet in height above high water. The sand is fine and of a grayish white color. The seaward slope of the hills is abrupt, that base washed by storm tides, the other slopes, in many cases equally steep, though usually more gentle, particularly those to the rear. The general breadth of the range is 100 yards, or thereabouts, with many depressions through which, in storms, the sea finds a passage to the waters of the bay. From their crests to the low flats in the rear, the hills are generally covered with isolated tall stalks of a coarse grass, *aiding* in retaining the light sand in position. The flats, or "meadows,"

are but a few inches above water and are frequently flooded. There are no trees, and only here and there a few patches of bayberry and whortleberry bushes are to be seen. Seaward, from the foot of the sand knolls, the beach slopes very gently for about 30 or 40 yards, then, at what has been taken as the high-water line, rather abruptly—the distance from this crest or line to low water being some 30 yards. About 100 yards beyond low-water line there seems to be a sort of bar, or shoal, so that the sea breaks pretty heavily for a breadth of near 200 yards from that line. There had been during the night a strong wind from the east, and a stiff breeze from that quarter was blowing during the examination, rendering it impossible to ascertain accurately the position of the high and low water lines.

The highest point of the line A B is about where it meets the prolongation of the seaward base of the hills, and is about six feet above high-water mark; at the other depressions in the range of knolls on this part of the coast, the corresponding points may be from 8 to 10 feet above the same level. These narrow valleys are seldom more than 20 yards in width. Although the line A B is longer than some others, it has been supposed the most favorable, as requiring the least excavation, the sand hills being higher at the narrow points. A survey can alone decide the best location, should it ever be deemed proper to attempt cutting an inlet through. The channel from the mouth of the Metedeconk passes quite close to the edge of the flats near Mr. Herbert's, within 50 yards, it is said. Those familiar with the bay state that a short distance lower down is a bar, which prevents vessels drawing more than about six feet from getting up to the river. The latter is apparently quite wide near its mouth, but is narrow at Burrsville, some five miles or so inland, where both branches are crossed by short bridges, and where the depth is not sufficient for vessels drawing five feet. The pine cord-wood is usually lightered down from this village for a distance of 1½ mile to the vessels, or the four or five miles to the mouth of the Metedeconk, where they are anchored. Small vessels, generally of about 100 tons burden or carrying some 60 cords of wood, and not many of these, with small wrecking vessels are, so far as I learned, all that ever come near this river, or even close along the Atlantic coast, unless in very smooth weather. Only such can enter the inlets. Squam inlet is very narrow, and vessels drawing five or six feet find difficulty in going in. It is said to close every three or four years. Then, when a good head of water is obtained within, the people turn out, cut a narrow channel through, and a new inlet is formed, which gradually works a quarter or half mile to the north, and is then closed again, and so on.

It is stated that an inlet, called Cranberry inlet, formerly existed about five or six miles below Mr. Herbert's, which closed some 40 or 50 years ago, and has since remained in that condition. From these facts, from what occurs at the other inlets, from the character of the coast, from the exposure of the mouth of the inlet to the action of the violent storms from northeast to southeast, &c., it is hard to believe that one cut through where proposed would keep open, or, if it did, a bar would probably form at the outlet which would render it useless, or nearly so.

In a gale from the east it would be almost certain destruction to a vessel to attempt to enter such an inlet.

The only government property that I could find anywhere was house of refuge No. 8, a mile or two above Mr. Herbert's, safely stowed away behind the sand-hills. How it could be protected by cutting an inlet through where proposed is not seen. Any government property even

Lieutenant Colonel of Engin

Brevet Major General A. A. HUMPHREYS,
Chief of Engineers U. S. Army, Headquarters
Corps of Engineers, Washington, D. C.

N 8.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., June 24, 1

GENERAL: The petitions of pilots and the board of underwri the city of Philadelphia for the removal of certain obstructions fr Delaware river, addressed to the Secretary of the Treasury, refer him to the War Department, and thence to these headquarte report, are herewith respectfully returned with the statement th matter was committed to Lieutenant Colonel Stewart, corps of neers, who was instructed to make such examinations in relation t as might be necessary to a proper understanding of the que involved. His report, of which an extract is given below, will aff the information at present attainable. He says:

I have the honor to report that in accordance with the request contained in lett headquarters corps of engineers, dated May 27, 1868, having been furnished by th tesy of Messrs. S. & J. L. Flanagan with a tug, pilot, &c., an examination was m the 16th instant, at low water, of the wrecks reported as obstructions to naviga Delaware bay, in the petitions, &c., referred to the War Department by indorse the Secretary of the Treasury, under date of May 22, 1868.

The more important of these wrecks, stated to be a brig of some 300 to 500 ton with coal, was sunk at anchor on or about the 11th of March, 1868, and lies in nea channel, here upwards of a mile wide, Duck river light bearing southwest, (so west.,) Liston's tree nearly northwest by west-half-west, (north, 63° west.) At lo there were 20 feet alongside and 15 feet over the vessel. By Coast Survey map c ware bay and river, published in 1848, scale , the $\frac{1}{80000}$ general depth in this vi about 20 feet, and that agrees also with the statement of the pilot.

The mainmast of the brig is still standing, foremast displaced and inclined up st

19 to 20 feet, which is the general depth according to chart and hearsay. This vessel, supposed to be about the same size as the other, is on the western edge of the channel, and, it would appear, has settled almost entirely below the bed of the bay. It is not much of an obstruction, and may continue to settle to the general level of the bed or below it. Its position is marked by daylight by a spar-buoy similar to that at first wreck mentioned. As yet these obstructions do not appear to have caused any material change in the bed near them.

It is stated by those interested in removing wrecks, that the brig, which seems to be the only serious obstruction of these two, could be raised or removed for $6,000 or $7,000.

* * * * * * * *

The sketch or tracing forwarded herewith gives the approximate position of wrecks.

It is recommended that the wreck of the brig be removed, and that an appropriation of $6,000 for that purpose be made.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Major General J. M. SCHOFIELD,
Secretary of War.

APPENDIX O.

UNITED STATES ENGINEER OFFICE,
27 *West Houston street, New York, September* 10, 1868.

GENERAL: I have the honor to transmit herewith a report on the progress and condition of the works of improvement of the Hudson river between Troy and New Baltimore, during the past fiscal year.

* * * * * * *

INFORMATION SUPPLIED TO CONFORM TO THE REQUIREMENTS OF ACTS OF CONGRESS.

1. Result of survey or re-survey with plan adopted, and items of expenditure under that plan. The plan adopted was that laid down in my report of November 9, 1866, the principles of which were indorsed by a special board of engineers, convened for that purpose at Albany. This plan looked to the directing of the currents by longitudinal dikes; to the removal of obstacles; to the free flow of the flood and ebb, and to the increase of navigable depth by these means, and by dredging. The dikes were generally to be at the height of mean high water, and it was not the specific object of the dikes to increase the scour, this being generally sufficient.

The facts obtained from the surveys just completed have justified the propriety of these rules and principles. The modifications of the original plan, which are those of detail only, and to be expected as the result of a recent and accurate survey, will be set forth in the concluding portions of this report.

2. The amount that is required for the entire and permanent completion of the work is $511,116 47, and probably $20,000 per annum for dredging between Troy and Albany.

3. The amount that can be profitably expended upon the work during the present fiscal year is $176,000.

4. The collection district in which the work is situated is the 14th.

5. The work is located near Albany, New York, a port of entry.

6. The amount of revenue collected at Albany, for the last fiscal year, was $101,641 81.

7. The amount of commerce and navigation to be benefited is estimated at $500,000,000.

8. Abstract of proposals, with names of bidders, sent herewith.
9. Abstract of contracts, with names of contractors, sent herewith.
10. Abstracts of contracts for each class of materials, and labor, sent herewith.
11. A statement of cash received and expended during the fiscal year; also amount of appropriation, June 30, 1868, and amount required for the year ending June 30, 1870.

APPROPRIATION OF 1864 FOR REPAIR OF HARBORS ON THE ATLANTIC COAST.

Balance available July 1, 1867, as per last report	$8,876 24
Expended during the year	8,294 25
Balance available July 1, 1868	681 99

APPROPRIATION FOR IMPROVING HUDSON RIVER, NEW YORK.

Balance available July 1, 1867, as per last report	$32,674 48
Appropriation for the year 1867	305,188 00
	337,862 48
Expended during the year	158,466 52
Balance available July 1, 1868	179,395 96
Total available July 1, 1868, (two appropriations)	180,077 95
From which is due the United States for revenue tax from appropriation for repairs of harbors on the Atlantic coast.	$138 48
Appropriation for improving Hudson river	102 94
Total	241 42

Congress also made an appropriation on the 25th July, 1868, from which the Secretary of War has allotted $85,000 for improving Hudson river, New York.

APPROPRIATION FOR EXAMINATIONS AND SURVEYS ON THE ATLANTIC COAST, APPLIED TO SURVEY OF THE HUDSON RIVER, NEW YORK.

On hand July 1, 1867	$471 85
Received during the year	2,950 00
	3,421 85
Expended during the year	3,661 01
Balance due from the United States	239 16

Balance available July 1, 1868, unknown. The amount required to be appropriated for the fiscal year ending June 30, 1870, is $160,000.

CONDITION OF THE RIVER.

Under this head will be enumerated what has been and what remains to be done for the entire and permanent completion of the works. The

course of the river will be divided in sections, corresponding to those enumerated in my report of November 9, 1866.

FIRST SECTION, INCLUDING NEW BALTIMORE AND COEYMAN'S.

The width of the river at New Baltimore, 850 feet, about, is very small, (comparing in this respect very unfavorably with the width above,) when we take into consideration, likewise, the fact that dikes built by the State commissioners principally, the New Baltimore, Coeyman's, and Schodack dikes, cut off the flood-tide working up the side channels, and thus diminish the original quantity of the flood, the necessity for some compensation is rendered more apparent. It is proposed, therefore, to cut off the face of Houghtailing's island, so as to increase the width at New Baltimore to 1,100 feet.

The improvement already commenced in cutting off the face of Mull's island will give an east channel of 950 feet wide at Barren island. The west channel at this place, though shoal, being likewise open for the advance of the flood. Along the New Baltimore dike it is proposed to excavate a channel 11 feet deep, 300 feet wide, 50 feet from the dike, and nearly parallel with it. This eastern channel, the sounding of which was made previous to certain dredging done by the State commissioners at the shoalest spot, is already much used for navigation, and the removal of the face of Mull's island will cause the great bulk of water to seek its downward passage through this outlet.

The west channel will naturally, in process of time, decrease its present limited depth. The improvement of Mull's island will be completed this season. Above this island the channel crosses to the west bank, and is called Coeyman's cross-over. It is proposed to dredge this channel to a width of 300 feet and to a depth of 11 feet.

From the west bank a concave dike is designed and represented upon the drawing. The object is to direct and throw upon the opposite shore the great body of water, which in its descent is now divided into two channels separated by Coeyman's bar. This dike, in preventing a division of the descending waters and giving a proper direction to them, would likewise be beneficial in retaining the volume of water along the shore of Mull's island and the New Baltimore dike.

SECOND SECTION, ABOVE AND BELOW CASTLETON.

Schodack dike, built by the State commissioners, was intended to prevent the descent of water through a side channel, but in so doing a portion of the flood-tide has likewise been cut off. The soundings were made prior to the completion of this work, the effect of which is, therefore, not known.

From this dike to Cedar Hill bar there is no place with less than nine feet draught at mean low water, and this draught is confined to limited localities. It is supposed that this portion of the channel after the works of improvement shall have been completed, will improve itself, assisted perhaps by dragging or plowing for a short period. Schodack island, between Castleton and Schodack dike, will probably need revetting, also a portion of shore of Shad island opposite. The shore above the upper end of Castleton dike requires protection, and an extension of the dike is represented with this object.

The next obstruction is Cedar Hill bar, which at low water is a decided impediment to navigation. A moment's glance at the map will reveal the fact that the principal cause of its formation lies in the construction

of the old State dam, which is represented in red. This obstacle caused a piling up and check of the descending waters until a head was obtained sufficient to generate the required velocity for discharge. The result has been a bar above and a scooping out below. This dam is under contract for removal this season. A channel 300 feet wide and 11 feet deep at mean low water should be dredged over the bar.

A dike is in process of construction connecting Campbell's and Cow islands. This work is necessary to receive and direct the current coming from the opposite bank and deflected at Parda Hook. A dike is commenced leading from Cedar Hill to Schermerhorn island to sustain and direct the volume of water, but an interval will be left in the dike above Schermerhorn island to allow the flood to come up through the west channel. It is not impossible that hereafter it may be deemed best to close this gap, owing to certain other inconveniences; but I am unwilling to cut off the supply of the flood up the main channel unless there should be imperative reasons therefor. This gap should, if closed at all, be filled with a dike not higher than low water.

The river is deflected by the elevated point at Staats over to Bear island and to the rocky point called Parda Hook. Bear island is washing away, as likewise the space between it and the point. A concave dike is designed to run from the old wharf on the island to Parda Hook, for shore protection, as likewise to direct and sustain better the mass of descending waters. The shore of Bear island above the wharf should be revetted.

THIRD SECTION, FROM BEAR ISLAND TO ALBANY.

Austin's rock, opposite lower end of Overslaugh dike, and the Overslaugh rock, lying in midchannel about half a mile above, and a very dangerous obstacle, should be blasted and removed. The old State dam, opposite to the last-named rock, has been the cause of the formation of a very large shoal, which has encroached upon and materially narrowed the channel, and should be taken up.

Before leaving the lower part of the Overslaugh dike it will be observed that the channel contracts suddenly to less than one-half of its former dimensions, and this nearly opposite to the State dam. The removal of this dam would, therefore, seem to be a remedy. Experience may prove, however, that while this operation would insure a decided benefit, it might not be a complete remedy. In such event a parallel dike about 3,000 feet long, of a concave form, would produce the necessary effect.

Further up the dike is another State dam of singular shape, projecting dangerously into the channel, and likewise injuriously deflecting the current away from the line of dike.

Cuyler's dike, built by the State commissioners, it is proposed to extend down stream as far as Duow's Point, with the object of protecting the point, against which the force of the ebb now strikes, as well as to give a good shoot to the current. This work will be executed during the present season.

From the lower end of the Overslaugh dike to the deep water in front of Albany, nine feet, and in most places 10 feet at low water, can now be carried, and it is believed that the improvements in progress will gradually increase the depth of the channel. Assistance may be given from time to time by dragging or plowing.

FOURTH SECTION, BETWEEN ALBANY AND TROY.

The railroad bridge is undoubtedly an obstacle to the flood and ebb, and to make the matter worse, the contractors for excavating the canal basin and others were in the habit, until arrested by the interference of the government, of depositing the dredged materials above the bridge in the angle formed by it with the east bank of the river. A large shoal extending over two-thirds of the width of the river is the consequence.

Patroon's (lower) island contracts unduly the width of the river. The flood current is quite perceptible, and should the improvements below give much increase to this velocity it would become a question to increase the width by cutting away the channel face of the lower end of the island. The further the flood current can be pushed up the river the greater will be the damming back of the back-water and the consequent rise at Troy with each tide. A concave dike is designed leading up from the wharf at Bath to a ledge of rocks on the margin of the channel. Opposite its upper end is a State dam, which has been a principal cause of the collection of a large gravel bank, obstructing the navigation, and known as Fish House shoal and Kellogg's shoal. This dam should be removed, as likewise the extremity of another above and on the opposite bank of the river.

The outlet between Cuyler's and Patroon's (upper) island was closed in 1867 by a dike conforming well to the direction of the channel and of the existing dikes. This structure was built to keep out of the channel a large quantity of material washed down from the side channel. From the lower end of this it is proposed to run out a concave dike to sustain and direct the body of water which here crosses over to the east bank, as shown by the channel lines upon the map. A part only of the old dike will be included in this design. A new dike or the repairs of the old dike would here be necessary. The new dike could be placed in a better direction, and it is believed would actually cost less than to repair the existing one.

At the lower end of Hillhouse island we come upon a narrow gorge, formed on the east by the natural high bank of the river, and on the west by a high revetment or dike, this contraction continuing until we pass Burden's wharf.

It is proper to remark here that the sole remedy to this state of things would be to cut away the revetments and dikes, and thus restore its proper width to the river. Since the dike was built the wharves at the nail works and at Burden's have been run out and the length of the contracted reach increased. The idea that contraction was equivalent to improvement of the river seems to have been prevalent in this section. The evil sure to result has not been dwelt upon. Not only has the quantity of back-water in each tide been thereby diminished to the injury of the whole river, but the velocity of the confined freshets so increased as to send down gravel, filling up channels as far as Albany.

Waste spaces, so valuable for the collection and deposit of gravel during freshets, have been obliterated, and the larger material has now no other course than down the main channel. There is nothing, I fear, to be done for most of the space between Albany and Troy except to dredge and continue dredging.

Between Troy and the sloop lock at the dam, no survey has been made; it is thought this should be provided for by an appropriation, with a view to the improvement of the channel leading up to the lock. Many impediments here exist prejudicial to the trade through the northern canal.

Relative heights of tides and freshets between New Baltimore and Troy.

Condition of stream.	New Baltimore.	Coeyman's.	Castleton.	Albany.	Troy.
Mean low water	0.00	+ 0.43	+ 0.85	+ 1.35	+ 2.24
Mean high water	+ 3.51	+ 3.34	+ 3.57	+ 3.76	+ 4.00
Lowest low water	— 2.27	— 1.57	— 1.22	— 0.66	+ 1.30
Highest high water*	+ 4.40	+ 4.16	+ 4.38	+ 4.82	+ 4.80
Freshet, June 18, 1867	+ 4.51	+ 5.52	+ 6.28	.....	+ 11.50
Freshet, August 17 and 18, 1867	+ 5.49	+ 5.57	+ 5.68	+ 7.17	+ 8.50
Freshet, May 22, 1868	.....	.....	.....	+13.62	

* Probably a slight freshet.

NOTE.—Mean low water at New Baltimore is taken as the datum line for the levels, and all the above heights refer to that according to their signs.

The low-water slope between New Baltimore and Coeyman's is 2.4 inches to a mile.

The low-water slope between Coeyman's and Castleton is 1.16 inch to a mile.

The low-water slope between Castleton and Albany is 0.72 inch to a mile.

The low-water slope between Albany and Troy is 1.6 inch to a mile.

The mean rise and fall at New Baltimore is 3.51 inches.

The mean rise and fall at Coeyman's is 2.91 feet.

The mean rise and fall at Castleton is 2.72 feet.

The mean rise and fall at Albany is 2.41 feet.

The mean rise and fall at Troy is 1.76 foot.

There is a falling off of the tides between New Baltimore and Coeyman's, a distance of little more than two miles, of 0.6 foot, while the level of high water is actually less at Coeyman's than at New Baltimore. These facts indicate that there is great room for improvement between these places. The present observations at New Baltimore give 3.51 feet as the mean rise and fall, instead of 3.69 feet, as in my former report quoted from Hughes.

Observations to determine additional points in the curve of mean low water from Troy to New Baltimore, particularly where the charts indicate obstacles to the flow of water—observations on the velocity and direction of the flood-currents, and of the effects of the works constructed and recommended to be constructed, and additional observations of the ebb currents and of the movement of the bed of the river—should, as opportunity may offer, be made. The information sent with the chart comprises all that the surveyor, who has been indefatigable in his duties, was able to compile up to this time. A short synopsis of the principles and mode of proceeding adopted for the improvement of this river will, it is thought, not be out of place. Contractions of the river have been carefully avoided by the engineer in charge. Abstract reasoning upon the effects of such a course was sufficient, and the conclusions arrived at have, it is thought, been fully verified by the facts developed in the charts sent herewith. With the enormous scour created by this confinement of the freshets, a draught of water between seven and eight feet mean low water is all that has been maintained between Albany and Troy. It was not foreseen by the advocates of contraction that the power required to

move pebbles and gravel would likewise supply these as fast as it removed them. Under the circumstances of this river, the velocity of the currents should never by artificial means have been increased beyond that necessary to move the light materials of the bottom, as sand and mud; nor was it, in order to secure and maintain a good permanent depth, ever required to do more (after dredging) than to guide the current by single longitudinal dikes, or in certain cases by low double (parallel) dikes, amply sufficient to have kept a large volume of water moving without sensible waste through the principal channel. Acting upon such principles, the freshets would have had room for expansion, and their power would not have been concentrated upon the work of bringing down large pebbles and gravel, to the injury or deterioration of the upper and lower navigation of the river. The magnitude of the injury done is manifest, from the fact that the greater portion of navigation through the canals is locked in and out at West Troy and above Troy. In the lower part of the river, as far up as Albany, the prospect for a permanent improvement of the river is flattering. In this portion the endeavor should be to lead up the flood and direct the descending waters in large volumes through the main channel. For these objects the channels at the New Baltimore dyke, the cross-over at Coeyman's, and the bar at Cedar hill, should be deepened as early as possible, and the dikes at Coeyman's and Parda Hook commenced. These in addition to the works now under way at Cow island and Cedar hill. It is thought that means more simple and inexpensive than dredging can be used to obtain the requisite depth at most places between New Baltimore and Albany, taking into consideration the assistance to be derived from the increased volume of water which the works recommended must send through the channels. The old State dams everywhere have proved a nuisance, and should be immediately removed.

In connection with obstructions it is necessary to call attention to the railroad bridge at Albany. This structure, having seven piers and a draw-pier obstructing the effective water-way at Albany, has been permitted to be built, and probably acquiesced in by the citizens of that place, under the mistaken notion that whatever damage might result to the navigation to Troy, it could not impair that to Albany.

Obstructions to the flow of water in tidal rivers, however, act like a two-edged sword, and cut both ways. The quantity of tidal back-water above the bridge has been decreased, and with this the scour below the bridge. It is the object of the improvement to send the flood current as far up as possible, in order to increase at each tide the back-water at Troy, and the obstruction of the bridge is a formidable obstacle to this result. A tubular or suspension bridge, with sufficient span to leave unobstructed the necessary water-way, could be easily constructed; and I note the fact here, because there is a project of building another railroad bridge lower down to replace the present, and the legislature of New York should be requested to consider and regulate the matter. It is a serious question whether, if it should hereafter be determined to widen the river above Albany, at the places mentioned in a former portion of this report, it would practically obtain the object so long as the obstruction of this bridge should remain; and my opinion is, that without improvement sufficient to maintain a permanent depth once dredged, there would be required of annual outlay at least $20,000 for the channel between Albany and Troy.

Estimate to complete the improvement of the Hudson river according to plan submitted.

Cutting off face of Houghtailing's island, damages to private property, 24 acres, at $100		$2,400 00
Excavation, 391,000 cubic yards, at 20 cents		78,200 00
Half dike, 1,320 lineal feet, at $6		7,920 00
Shore protection, 920 lineal feet, at $3		2,760 00
Dredging channel at New Baltimore dike, viz: 129,000 cubic yards, at 20 cents		25,800 00
Finishing Mull's island improvement		49,000 00
Construction of dike at Le Roy Hook, viz: 2,840 lineal feet		58,200 00
Shore protection between Castleton and Schodack dikes, viz: 3,200 lineal feet, at $3		9,600 00
Shore protection at Shad island, 1,600 lineal feet, at $3		4,800 00
Extension of Castleton dike, viz: 1,000 feet of half dike, at $6, $6,000; 700 feet of full dike, at $7 50, $5,250		11,250 00
Finishing Cow and Campbell Island dike		40,000 00
Finishing Cedar Hill dike		45,500 00
Dredging Cedar Hill bar, viz: 72,800 cubic yards, at 20 cents		14,560 00
Removing old State dam		2,000 00
Dike at Parda Hook, 3,660 lineal feet		46,500 00
Shore protection Bear island, viz: 1,200 lineal feet, at $3		3,600 00
Removing Austin's rock, 1,900 cubic yards, at $13		24,700 00
6,000 lineal feet parallel with Overslaugh dike, at $10		60,000 00
Removing Overslaugh rock, 468 cubic yards, at $13		6,084 00
Removing 775 lineal feet of old State dam		2,712 00
Extension of Cuyler's dike, viz: 1,650 lineal feet		16,000 00
Dike parallel with Cuyler's dike, 2,500 lineal feet, at $9		22,500 00
Dredging channel parallel with Cuyler's dike, 100,000 cubic yards, at 30 cents		30,000 00
Dike above Bath, 5,693 lineal feet		55,297 00
Removing old State dam		2,600 00
Dike to replace old United States dike, 1,820 lineal feet		15,470 00
Removing old State dam		2,700 00
Dredging channel 250 feet wide, and nine feet at mean low water, from Albany to Troy, viz: 316,000 cubic yards, at 30 cents		94,800 00
Expenses of dragging and plowing the channel, to increase and make uniform the depth at various places between Albany and New Baltimore		30,000 00
Expenses of further survey		10,000 00
Total		775,953 00
Balance available July 1, 1868	$179,836 53	
Appropriated July 25, 1868	85,000 00	
		264,836 53
Balance asked to be appropriated		511,116 47

To compare estimates of this date with that made November 9, 1866:

Present estimate from commencement to completion	$984,304 47
Estimate of 1866	862,297 75
Excess of present estimate	122,006 72

When it is considered that in 1866 the engineer had to rely upon old maps and charts from which to deduce his quantities, differing in many respects from those obtained from the recent survey, the difference of the two estimates is not surprising, and for the amount involved, $984,304 47, will not be considered great. It must likewise be stated that the present estimate includes several items which are of probable necessity only, viz:

6,000 feet of dike parallel to Overslaugh dike	$60,000
2,500 feet of dike parallel to Cuyler's dike	22,500
Austin's rock, 1,900 cubic yards or rock excavation	24,700
Dike above Bath	55,927
Dike to replace old United States dike	15,470
Total	178,597

Respectfully submitted.

JOHN NEWTON,
Lieut. Col. Engineers and Brevet Maj. Gen. U. S. A.

Abstract of contracts for each class of materials and labor for the Hudson River improvement, from July 1, 1867, to June 30, 1868.

Date.	Contractor.	Nature of work.	Quantity.	Rate.
1867.				
Aug. 10	J. L. Powley	Driving piles ..... lineal feet..	30,000	5 cents per lineal foot.
13	Thomas Flood	Timber work on full dike ..... running feet..	3,000	55 cents per running foot.
13	..... do	Grading and paving ..... square yards..	10,000	41 cents per square yard.
13	..... do	Rubble stone ..... cubic yards..	10,000	$1 50 per cubic yard.
13	..... do	Piles ..... lineal feet..	3,000	10 cents per lineal foot.
14	John Hutchinson	Iron bolts ..... pounds..	3,000	8 cents per pound.
14	..... do	Iron rods ..... pounds..	4,000	6½ cents per pound.
14	Emory R. Seward	Slope wall stone ..... cubic yards..	5,000	$1 90 per cubic yard.
14	Simeon Cunliff	Spikes ..... pounds..	10,000	5½ cents per pound.
24	Tobias S. Van Hovenbergh	Dredging ..... cubic yards..	Mull's island	21 cents per cubic yard.
30	M. O. Caldwell	Slope-wall stone ..... cubic yards..	4,000	$1 79 per cubic yard.
Sept. 3	William Fuller	Rubble stone ..... cubic yards..	6,000	$1 34 per cubic yard.
Oct. 26	..... do	Slope-wall stone ..... cubic yards..	2,000	$1 75 per cubic yard.
1868.				
Feb. 19	Darius Davis	Piles ..... lineal feet..	270,000 to 350,000	9 cents per lineal foot.
19	..... do	Spikes ..... pounds..	35,000 to 48,000	4¼ cents per pound.
20	J. L. Powley	Timber work on half dike ..... running feet..	3,200	35 cents per running foot.
21	Templeton & Payne	Driving piles ..... lineal feet..	60,000 to 79,000	3½ cents per lineal foot.
22	Plant's Manufacturing Company	Iron bolts ..... pounds..	16,000 to 22,000	5.94 cents per pound.
27	Emory R. Seward	Slope-wall stone ..... cubic yards..	3,000	$1 50 per cubic yard.
27	C. B. Benson	Driving piles ..... lineal feet..	180,000 to 236,000	3¾ cents per lineal foot.
28	Samuel Strong	Rubble stone ..... cubic yards..	50,000 to 65,000	$1 per cubic yard.
29	R. N. Gere	Iron rods ..... pounds..	40,000 to 50,000	4¼ cents per pound.
29	..... do	Dredging ..... cubic yards..	2,000	45 per cubic yard.
29	..... do	Abutment timber work ..... running feet..	1,200 to 1,500	7½ cents per running foot.
29	White & Boynton	Timber work on full dike ..... running feet..	15,000 to 21,000	40 cents per running foot.
April 10	Emory R Seward	Hemlock timber ..... feet..	650,000 to 850,000	$20 40 per M feet.

I certify that the above abstract is correct.

JOHN NEWTON,
Lieut. Col. of Engineers and Bvt. Major General U. S. A.

'ract of contract for work and materials entered into by the United States from July 1, 1867, to June 30, 1868.

; of act.	Contractors.	Classes.
67		
10	J. L. Powley	Driving 30,000 feet of piles, at 5 cents per foot.
13	Thomas Flood	Wood work on 3,000 feet of dike, at 55 cents per running foot.
	Do	Grading and paving 10,000 square yards, at 41 cents per square yard.
	Do	10,000 cubic yards of rubble stone, at $1 50 per cubic yard.
	Do	3,000 piles, at 10 cents per foot.
14	John Hutchinson	3,000 pounds of bolts, at 8 cents per pound.
	Do	4,000 pounds of rods, at 6½ cents per pound.
	Emory R. Seward	5,000 cubic yards of slope wall, at $1 90 per cubic yard.
	Simeon Cunliff	10,000 pounds of spikes, at 5½ per pound.
24	Tobias S. Van Hovenbergh	Dredging Mull's island, at 21 cents per cubic yard.
30	Marshall O. Caldwell	4,000 cubic yards of slope wall stone, at $1 79 per cubic yard.
3	William Fuller	6,000 cubic yards of rubble stone, at $1 34 per cubic yard.
26	Do	2,000 cubic yards of slope wall stone, at $1 75 per cubic yard.
68		
19	Darius Davis	270,000 to 350,000 feet of piles, at 9 cents per foot.
	Do	35,000 to 48,000 pounds of spikes, at 4½ cents per pound.
20	Joseph L. Powley	3,200 feet of half dike timber work, at 35 cents per running foot.
21	Templeton & Payne	Driving 60,000 to 79,000 feet of piles, at 3½ cents per foot.
22	Plant's Manufacturing Co	16,000 to 22,000 pounds of bolts, at 5 $\frac{34}{100}$ cents per pound.
27	Emory R. Seward	3,000 cubic yards of slope wall stone, at $1 50 per cubic yard.
	Caldwell B. Benson	Driving 180,000 to 236,000 feet of piles, at 3¼ cents per foot.
28	Samuel Strong	50,000 to 65,000 cubic yards of rubble stone, at $1 per cubic yard.
29	R. N. Gere	40,000 to 50,000 pounds of rods, at 4½ cents per pound.
	Do	2,000 cubic yards of dredging at 45 cents per cubic yard.
	Do	1,200 to 1,500 feet of abutment timber work, at 7½ cents per running foot.
	White & Boynton	15,000 to 21,000 feet of full dike timber work, at 40 cents per running foot.
10	Emory R. Seward	650,000 to 850,000 feet of hemlock timber, at $20 40 per M feet.

certify that the above abstract is correct.

JOHN NEWTON,
Lieut. Col. Engineers and Bvt. Major General U. S. A.

certify that the above abstract is correct.

JOHN M. WILSON,
Major Engineers and Brevet Colonel U. S. A.

Abstract of proposals for work and materials for improvement of the navigation of Hudson river, New York, received from July 1, 1867, to June 30, 1868.

Number.	Names of bidders.	Opened August 10, 1867.									Opened Aug. 22, 1867.	Opened Aug. 30, 1867.		Opened Oct. 18, 1867.	Opened Feb. 11, 1868.		
		Furnishing piles.	Rubble stone.	Driving piles.	Slope wall stone.	Grading and paving.	Wood work.	Iron rods.	Bolts.	Spikes.	Dredging Mall's island.	Rubble stone.	Slope wall stone.	Slope wall stone.	270,000 to 315,000 feet of piles.	50 to 65,000 cubic yds. of rubble stone.	Driving 240,000 to 315,000 feet of piles.
		Cents per ft.	*Dolls. pr. cub. y.*	*Cents per ft.*	*Dolls. pr. cub. y.*	*Cents pr. sq. yd.*	*Dolls. pr. r'n. ft.*	*Cents per lb.*	*Cents per lb.*	*Cents per lb.*	*Cents pr. cub. y.*	*Dolls. pr. cub. y.*	*Dolls. pr. cub. y.*	*Dolls. pr. cub. y.*	*Cents per ft.*	*Dolls. pr. cub y.*	*Cents per lb.*
1	Wesley Smith	12	.....	10	.....	.....	1 25	8	9	7	.....	.....	.....	.....	.....	.....	.....
2	George Schofield	11¼	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	J. L. Powley	.....	.....	5	.....	.....	0 65	.....	.....	.....	.....	.....	.....	.....	11	.....	4½, 5
4	William P. Van Aicken	13	.....	8	.....	.....	1 75	.....	11	7½	.....	.....	.....	.....	.....	.....	4½, 3½, 4, 4½, 5
5	Templeton & Payne	.....	.....	5½	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6	Simeon Cunliff	.....	.....	.....	.....	.....	.....	6½	9	5½	.....	.....	.....	.....	.....	.....	.....
7	Dewitt C. Stiles	.....	.....	.....	.....	69	.....	.....	.....	.....	.....	.....	.....	.....	.....	1 75,1 18	.....
8	M. O. Caldwell	.....	1 64	.....	1 99	.....	.....	.....	.....	.....	.....	1 43	1 79	.....	.....	1 44	.....
9	John Hutchinson	.....	.....	.....	.....	.....	.....	6½	8	5½	.....	.....	.....	.....	.....	.....	.....
10	William H. Lyon	.....	.....	.....	.....	.....	.....	7½	10	6½	.....	.....	.....	.....	.....	.....	.....
11	Jesse Boydton	.....	.....	17	.....	.....	1 00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	Thomas J. Strong	.....	.....	.....	.....	.....	.....	8½	9½	7	.....	.....	.....	.....	.....	.....	.....
13	Thomas Flood	10	1 50	20	2 00	41	0 55	.....	.....	.....	.....	1 65	2 25	.....	.....	.....	.....
14	N. Stanton Gere	18	1 88	9½	2 25	59	.....	.....	.....	.....	35	.....	.....	.....	.....	.....	.....
15	Emery R. Seward	13½	1 63	5½	1 90	70	0 80	10	10½	6½	24½	1 48	2 10	.....	12	1 45,1 37	4½
16	Levi Hayden	.....	.....	.....	.....	.....	.....	.....	.....	.....	40	.....	.....	.....	.....	.....	.....
17	James H. Sherrill	.....	.....	.....	.....	.....	.....	.....	.....	.....	39	.....	.....	.....	.....	.....	.....
18	Daniel Dodge	.....	.....	.....	.....	.....	.....	.....	.....	.....	34	.....	.....	.....	.....	.....	.....
19	B. B. Van Duzen	.....	.....	.....	.....	.....	.....	.....	.....	.....	29½	.....	.....	.....	.....	.....	.....
20	S. Cahill	.....	.....	.....	.....	.....	.....	.....	.....	.....	29	.....	.....	.....	.....	.....	.....
21	Alfred Lee	.....	.....	.....	.....	.....	.....	.....	.....	.....	24	.....	.....	.....	.....	.....	.....
22	Tobias S. Van Hovenbergh	.....	.....	.....	.....	.....	.....	.....	.....	.....	21	.....	.....	.....	.....	.....	.....
23	William Fuller	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1 34	.....	1 75	.....	1 44,1 24	.....
24	Samuel N. Payne	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4½
25	Thomas Briggs	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1 30,1 19	.....
26	James S. Beldon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1 35,1 24	.....
27	Nathan J. Snow	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
28	Place & Kilpatrick	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

29	Skinner & Arnold																
30	Ferguson & Carter																4¾, 5¼
31	L. W. Conner														19¼		
32	Jno. E. Harroun																
33	Henry J. Mowry														16	2 25	12
34	Sherrill, Strong, Flood & Sherrill														9½	1 49	7
35	Morgan Lewis														13½		
36	Waltons & Leonard																
37	Thos. C. Brainard																
38	White & Boynton														12½	1 37	5
39	Thomas Keeler														15	2 25	6
40	William B. Cooper														11¾		
41	Darius Davis														9	1 20	5
42	David F. Mink																
43	Albert E. Wooster														9¼		
44	S. Prior & Co															5 50	
45	H. S. Terbell																
46	Charles H. Smith														11		
47	A. P. Plant																
48	Edward McCloskey																
49	Phelps & Kimpland														13⅞		
50	Merrell & Gilbert														15	1 24	7¼
51	Samuel Strong														20	1 00	8
52	John Hutchinson																
53	Breth & Hatkins														11⅜		
54	W. R. Chamberlin																
55	George B. Anderson																
56	Asahel Clark																
57	R. Nelson Gere														11	1 24½	6¼
58	Caldwell B. Benson																3¾

Abstract of proposals for work and materials for improvement of the navigation of Hudson river, New York, &c.—Continued.

Number.	Names of bidders.	Opened Feb. 11, 1868.									Opened April 8, 1868.	Remarks.
		650,000 to 850,000 ft. of hemlock timber.	15,000 to 21,000 ft. of full dike timber work.	3,200 feet of half dike timber work.	1,200 to 1,500 feet of abutment timber work.	16,000 to 22,000 lbs. of bolts, nuts, & washers.	40,000 to 50,000 lbs. of rods, nuts, and washers.	35,000 to 48,000 lbs. of spikes.	3,000 cubic yds. of slope wall stone.	Dredging 2,000 cub. yds. more or less.	650,000 to 850,000 ft. of hemlock timber.	
		Dolls. pr. M ft.	*Dolls. pr.r'n. ft*	*Dolls. pr.r'n. ft*	*Dolls pr.r'n. ft*	*Cents per lb.*	*Cents per lb.*	*Cents per lb.*	*Dolls. pr.cub.y.*	*Dolls. pr.cub y.*	*Dolls. pr. M ft.*	
1	Wesley Smith	.....	5 00	3 40	1 25	.....	.....	.....	.....	1 10	.....	Material and labor to be furnished by the bidder.
2	Geo. Scholfield	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
3	J. L. Powley	.....	60a65 cts	25	.....	.....	.....	.....	.....	.....	.....	5,000 ft. timber work at 60c., and 5,000 ft. at 65c. per foot. 5,000 piles, and drive 5,000 at 4½c., and 5,000 at 5c. per ft.
4	William P. Van Aicken	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
5	Templeton & Payne	.....	75	55	.....	.....	.....	.....	.....	.....	.....	¼ of the driving at 3½c., ¼ at 4c., ¼ at 5c., ¼ at 4½c., and ¼ at 5c., or the whole at 4½c. per foot.
6	Simeon Cunliff	.....	.....	.....	.....	¾ at 7 ¼ at 6	5	4¾	.....	.....	.....	Offers 20,000 lbs. of rods, and 25,000 lbs. of spikes, at $1 75 above, $1 18 below Albany, N. Y.
7	Dewitt C. Stiles	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
8	M. O. Caldwell	.....	.....	.....	.....	.....	.....	.....	1 74	.....	.....	Rubble stone between Albany and Troy.
9	John Hutchinson	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
10	William H. Lyon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
11	Jesse Boydton	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
12	Thomas J. Strong	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
13	Thomas Flood	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
14	N. Stanton Gere	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
15	Emery R. Seward	24 40	70	80	30	9	7	5	1 50	70	20 40	$1 45 above, and $1 37 below Albany.
16	Levi Hayden	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
17	James H. Sherrill	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
18	Daniel Dodge	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
19	E. B. Van Duzen	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
20	S. Cahill	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
21	Alfred Lee	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
22	Tobias S. Van Hovenbergh	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

29	Skinner & Arnold					7½	5½	4½				
30	Ferguson & Carter	22 50	45	35	25			6				4½ for all the driving, except abutment, which is to be 2½c.
31	L. W. Conner	29 50										
32	John E. Harroun	24 90									20 90	
33	Henry J. Mowry	28 00				16	14	12	2 50			
34	Sherrill, Strong, Flood & Sherril	33 00	75	50	15	10	8	6½	1 85	70		Offer 20,000 yards of rubble stone.
35	Morgan Lewis	25 00									23 50	
36	Waltons & Leonard					6½	6½	5½				
37	Thomas C. Brainard					8	8	5½				Agent Lehigh Rolling-mill Company.
38	White & Boynton	22 00	40	40		6½			3 00	60		
39	Thomas Keeler	28 00	80	60					2 50			
40	William B. Cooper											
41	Darius Davis	21 75	53	38		6½	6½	4½	1 60		21 25	
42	David F. Mink		92	70								
43	Albert E Wooster											
44	S. Prior & Co								6 50			¼ of the rubble stone.
45	H. S. Terbell					8	8					Agent Sweitzer Bolt Company.
46	Chas. H. Smith											
47	A. P. Plant					5.94	6	4½				Plant's Manufacturing Company.
48	Edward McCloskey				15							
49	Phelps & Kimpland											
50	Merrell & Gilbert								1 70			
51	Samuel Strong								1 50			
52	John Hutchinson					6 15-16	5 11-16	4½				
53	Breth & Hatkins											Offers 75,000 feet.
54	W. R. Chamberlin										21 49	
55	Geo. B. Anderson										24 00	
56	Asahel Clark										35 00	
57	R. Nelson Gere	*17 50	2 90	1 95	7½	6½	4½	5½	1 65	45	25 00	*Refuses to enter into contract.
58	Caldwell B. Benson											

I certify that the above abstract is correct.

JOHN M. WILSON, *Major Engineers and Brevet Colonel U. S. A.*

I certify that the above abstract is correct.

JOHN NEWTON, *Lieut. Col. Engineers and Brevet Major General U. S. A.*

O 1.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., March 5, 1868.

SIR: I return herewith letters of the Hon. Z. Chandler, chairman of the Committee on Commerce of the Senate of the United States, of the 25th of January, 1868, with petition of citizens of the United States, praying an appropriation for removal of obstructions from Hell Gate, New York harbor, and of February 12, 1868, inclosing memorial of Chamber of Commerce of the State of New York, praying the removal of obstructions in the East river at Hell Gate, &c., referred to these headquarters for report, and submit a copy of a report of Lieutenant Colonel and Brevet Major General John Newton, corps of engineers, who was instructed to make the requisite examinations and estimates of the amount that would be required to remove the obstructions referred to.

This estimate for the first year's operations, which includes the removal of Pot rock, Frying Pan, Wag's reef, and Shelldrake rocks, is $378,000.

His views are concurred in.

It is suggested that the appropriation for the work include the operations on Coenties, Diamond, and Battery reefs, East river, under the general heading of the removal of the obstructions in New York harbor, for which it is recommended that $500,000 be appropriated for the first year.

Attention is invited to a letter from these headquarters of this date, in relation to the removal of obstructions at Battery, Diamond, and Coenties reefs, New York harbor.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Hon. E. M. STANTON,
Secretary of War.

O 2.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., February 8, 1868.

GENERAL: The inclosed copy of a petition for an appropriation for the removal of obstructions which impede the navigation of the East river approach to New York harbor at Hell Gate, and copy of letter from Hon. Z. Chandler, chairman of the Committee on Commerce, United States Senate, are transmitted for your information and report.

Your report of last year has been before Congress, but perhaps the magnitude of the operations involved in the improvement and the large amount requisite to carry them out may have had the effect of deferring legislation. It is suggested that you revise your former estimate with a view to reducing it, if possible. The amount asked for the first year's operations was $900,000, a large part of which was to be expended in costly machinery, such as current breakers, &c. Could not a much smaller sum be very usefully applied the first year in removing, by less expensive means, in whole or part, the most dangerous of the rocks in the order named in your report; that is, Pot rock, Frying Pan, Wag's

reef, &c.? What is the least sum that can be effectively applied as a beginning, in the first year, that will be of marked value to navigation?

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Lieut. Col. and Brevet Major Gen. JOHN NEWTON,
Corps of Engineers, 395 Canal Street, New York.

O 3.

NEW YORK, *February* 11, 1868.

GENERAL: I have the honor to acknowledge the receipt of department letter of the 8th instant, inclosing copy of a letter from the Hon. Z. Chandler, chairman of Committee on Commerce of the United States Senate, to the Hon. E. M. Stanton, Secretary of War, and copy of petition of citizens, praying for the removal of obstructions in Hell Gate, New York harbor, to the Senate and House of Representatives.

1. In department letter it is suggested that I revise my former estimate for effecting these operations with a view to reducing it if possible.

I will remark that my views have been distinctly stated in my report of January 21, 1867, and the reasons given there for the several items of estimate. It is proper to add here that a project for the improvement of Hell Gate, when the task was committed to me, had few advocates among practical men, owing to a disbelief of its successful prosecution in the existing state of the art of blasting under water; which, it may be added, was specially due to the many failures which had befallen various operations in this neighborhood. The introduction of nitro-glycerine as a blasting agent for the moment gave vague and undefined hopes that the project might be revised, under the stimulus of the acknowledged explosive effect of this new agent. But for all this, there was little sympathy manifested in the attempt to devise a sound, practical project, and no assistance whatever afforded; probably because there was so little really known on this subject, and no attempt had been made to systematize even that little.

Such was the condition of things when I took up the subject under the orders of the engineer department. It was at once evident that to attempt this difficult task without a defined system was to expose it to the fancies of inventors or speculators, and to a moral certainty of failure in the end, after much useless expenditure. The system adopted after much care, and the reasons therefor, have been very fully given in my report.

The particular machines described by me were not relied upon as the sole or even the best means of effecting the object desired, as my report will show; but their design was to demonstrate that no insuperable difficulty intervened to prevent a practical consummation of the work, and to furnish data for its estimate.

One thing became certain, that the boring should be conducted from a platform above water, but whether such platform should be supported upon tripods or arranged as designed in the report, was a matter of small moment. It is quite likely that both systems can be advantageously employed in the same work under different circumstances.

I have stated in that report, "before work is really undertaken, trials should be made and prosecuted until a good result is obtained," and I prefer this mode of commencement when little, as in such operations,

had been demonstrated by successful practice. But when the success of a system has once been shown, it would then be necessary that the appropriations for each year should follow in regular series, until the work has been completed. This would be essential, in order to guard against the cost exceeding the estimates of the report, though these, according to the terms of the law, which required estimates for a *completed* work, have been made to embrace, as nearly as possible, losses which might follow from the precarious chances incident to these operations at Hell Gate.

The total estimated cost for each cubic foot of rock removed was $1 64 in our present currency, which is not considered extravagant, as the comparison made in the report with the cost of removing Pot rock under Major Fraser's superintendence would demonstrate.

The report further states "that a serious and well-considered attempt to push the work will be the means of stimulating mechanical inventions suited to this end, which, with the experience gained from day to day, will not only expedite progress, but also materially diminish the cost, especially in the large item of removing the rock."

It is likely that the "current breakers" may be dispensed with, as I have been considering other means of removing the rock from the bottom, after blasting. It is not perhaps impossible to let this part of the work by contract.

2. I am requested to state whether a less sum than $900,000, the sum asked for the first year's appropriation, would not suffice. This reminds me that my report does not specify the sum needed for the first year, and the omission to do so probably arose from a recommendation in the report to conduct preliminary experiments in order to prove the efficiency of the plan before going further.

The department further asks, "could not a much smaller sum be very usefully applied the first year in removing by *less expensive means*, in whole or in part, the most dangerous of the rocks, * * * that is, Pot rock, Frying Pan, Wag's reef," &c. I am not certain that I entirely appreciate the meaning intended by the phrase I have interlined. To cover such meaning, I will state that charges of gunpowder placed in contact with the surface of the rock have not proved economical, in my opinion, after the rock has once been reduced to a flat surface, nor at all reliable afterwards for a further removal of its surface. What nitroglycerine may do under such circumstances has never, to my knowledge, been demonstrated.

I have recommended in the report that charges, so placed, should be first employed to blow off projecting parts, and such a process would naturally be continued as long as it was effective. For a further reduction of the rock, drilling and blasting should be the next resource. Drilling done by hand under water, supposing the current to permit the descent of the diving bell or armored divers, is too slow and expensive a process. The next alternative is a platform above water from which the drilling could be performed. These are the three modes of performing the work which suggest themselves.

As to the relative expense of the first and last method of removing the rock, I find that each charge fired in 1852 and 1853 cost, in gold, $22 35, and by my estimate the same charge producing greater effects in breaking up the rock, and the same effect in removing the debris, (including also drilling the holes,) would cost just double in currency. This close approximation of their cost, the difference between gold and currency being taken into consideration, proves that the estimate is not in fault, at least, by being too large.

I subjoin an estimate for the removal of Pot rock, Frying Pan, Wag's reef, and Shelldrake.

These rocks naturally go together. Pot rock and Frying Pan are so associated in position, and in the dangers to which vessels are subjected by them, that the removal of both should be effected as soon as possible; and the same remark applies to Wag's reef and Shelldrake. Again, the charges, on being fired at Pot rock or Frying Pan, Wag's reef, or Shelldrake, would afford a suitable place for drilling to proceed without loss of time.

For Wag's reef and Shelldrake I have had to rely upon the survey of Lieutenant Craven, of 1856, and the amount of rock to be removed from these has not been determined with the accuracy attained in the other cases, for which special surveys were made at my instance.

A drilling platform, derricks, a few scows, small boats, anchors, chains, and cables are estimated for. The "current breaker" is not included.

Estimate.

Machinery	$158,300
Docks, storehouses, magazine, &c.	18,000
Contingent	24,200
Blasting and removing rock	177,540
	378,040

Respectfully submitted.

JOHN NEWTON,
Lieut. Col. Engineers and Brevet Major General U. S. A.

[Indorsement.]

UNITED STATES ENGINEER OFFICE,
New York, March 2, 1868.

Respectfully returned. After a careful consideration of the matter, I would not desire to increase the estimate, nor, on the contrary, to decrease it. I have made another calculation which resulted in a decrease of about $30,000; but in an experiment in blasting at this difficult spot, where accidents are liable, it were best to allow some margin.

I do not ask, either, for money sufficient only for experimental knowledge, as I once thought of, because, if the rocks in Hell Gate are placed in the same bill with Diamond and Coenties reefs, likewise in the East river, it is evident that the experimental knowledge gained by operations at either of those reefs, in the more quiet portions of the river, would be available likewise for Hell Gate.

I respectfully refer to the concluding paragraphs of my report on Diamond and Coenties reefs.

JOHN NEWTON,
Lieut. Col. Engineers and Brevet Major General U. S. A.

O 4.

Survey of Hell Gate, East river.

ENGINEER DEPARTMENT,
Washington, February 9, 1867.

SIR: In obedience to the provisions of the act approved June 23, 1866, making appropriations for the repair, preservation, and completion of

certain public works, &c., I have the honor to transmit herewith a copy of the report of Brevet Major General John Newton, United States army, lieutenant colonel of engineers, on the survey of Hell Gate, New York.

General Newton submits estimates for three separate projects for the improvement, with channels of 26 and 24 feet in depth at mean low water.

The first includes the removal of all the rocks enumerated in his report, the construction of sea-walls, improvement of the middle channel, and the removal of Negro Head. The second includes the cost of removing that part of the middle reef known as Negro Head, Hen and Chickens, Flood rock, and Gridiron, thus throwing the eastern and middle channels into one. The third includes the removal of the smaller rocks and the construction of the sea-walls, but makes no provision for improving the middle channel, or otherwise interfering with the middle reef.

The third project, involving the least expenditure of money and greatly ameliorating the danger to navigation, essentially that recommended by the advisory council to the "commissioners relative to the encroachments and preservation of the harbor of New York," consisting of General Totten, chief engineer United States army, A. D. Bache, superintendent United States Coast Survey, and Commander (now Admiral) Charles Henry Davis, United States navy, dated September 30, 1856, is recommended as the best to be undertaken at present. The estimate for this project, giving a channel of 26 feet at mean low water, is $2,877,000, to be completed in four years. The amount required for the first year's operations, including purchase of machinery, will be $900,000. The entire completion of the improvement to be undertaken as the demands of increasing commerce shall warrant.

General Newton enters minutely into the method of conducting the work, the nature of the requisite machinery, &c., and his conclusions, derived from a close and careful study of the questions involved, are commended to the attention of the War Department.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Chief of Engineers.

Hon. EDWIN M. STANTON,
Secretary of War.

UNITED STATES ENGINEER OFFICE,
No. 7 Bowling Green, New York, January 21, 1867.

GENERAL: Having been assigned by department letter of July 21, 1866, to the duty of examining Hell Gate; and having been further instructed by letter of July 25, to make such examination with the view of its improvement for the purposes of navigation, and sufficiently in detail to present a plan and estimate for the necessary operations, I have the honor to present the following report:

Lieutenant Commanding C. H. Davis, assistant in the Coast Survey, made an examination of Hell Gate and a report, dated February 15, 1848. He states, "of the sailing vessels which enter Hell Gate passage, it is estimated that 1 in 50 sustains more or less injury by being forced by the violence of the current on the rocks and shoals. * * * The damages in this channel arise from the great strength of the currents, and the number and positions of the rocks and reefs. The strength of the current is such that sailing vessels can only stem its force or escape from it by a commanding breeze; but, as the main course of the *flood*

tide keeps the middle of the eastern channel, it is most secure for vessels coming from the westward with the tide to place themselves in the middle of the stream and follow its direction. * * *

"This plan, however, is inadmissible for any but small vessels, on account of two rocks, the Pot and the Frying Pan, which lie in or very near the midchannel, and in the way going to the eastward and westward. * * * There is a reef called the Wag's reef, which lies in the course followed by steamboats principally when coming from the eastward against a strong flood. It is their custom to keep close round Pot Cove, and run up under Hallet's Point, by which they avoid the strength of the flood. In this part they find an eddy current in their favor. But on the ebb, the greatest danger arises from the divergence of the current at a point marked A on the sketch, where the ebb tide branches off into three directions, to take the course of the three channels, and the main south (ship?) channel, the middle channel, and the eastern channel. The safe navigation depends here upon deciding sufficiently soon, at the point of separation, which channel shall be taken, and the neglect to do this, or a loss of control over the vessel for any reason, frequently results in being carried on the Gridiron.

"When a vessel that has attempted the eastern channel finds herself carried towards the Gridiron, her only chance for safety is to run for the middle channel, which is narrow and made precarious by the middle reef, the outer rock of which is the Negro Head. The Gridiron is, owing to the strong set of the tide on it, the most dangerous reef in the passage. The reef known as the Bread and Cheese, on the eastern end of Blackwell's island, is also very dangerous. Vessels are liable to go on it in the flood, when it is covered, by getting into the eddy near it with a light wind. The chief danger is on the ebb, and from the same cause as that which makes the Gridiron dangerous, that is, the strong set of the tide in that direction."

Lieutenant Commanding Davis then recommends the removal by blasting of Pot rock, the Frying Pan, and Wag's reef, and also that the middle reef be blasted so as to make a clear channel of sufficient depth for common vessels and steamboats between Flood and Little Mill rocks. That piers be built upon Hog's Back, the Gridiron, and Bread and Cheese, of stone sufficiently high to show above the surface of the water at least four feet, and that these piers be faced with wood, and provided with spring fenders. The piers should conform to the natural shape of the reef.

Bylander's reef, by the same report, is dangerously situated on account of the deep waters around it, but no recommendation, except to mark its position, is made. Lieutenant Commanding D. D. Porter, United States navy, under date of October 30, 1848, reports in favor of the plan of improvement of Lieutenant Davis, except the blasting of the middle channel reef, which is too difficult, and suggests it be entirely filled in with docks provided with spring fenders.

He recommends, likewise, the removal of certain small rocks not before mentioned: Bald-headed Billy, a rock opposite Gibbs's Point, and within fifty yards of Blackwell's island; a small and dangerous rock southward of Woolsey's bath-house; Scaley rock, and close to it Shell rock.

Hallet's Point, he states, should by all means be removed. "At tide it causes the eddies in Pot Cove, and on the ebb tide the eddies in East channel." * * * Toward the close of his report: "No one can form an idea of the number of vessels that go on shore during the course of a month. Fifty went on shore during the period I was occupied there, (two months,) and many of them were much injured." He sug-

gests, likewise, "a close examination of the shore at low water. Many rocks will be found to exist of a dangerous character, and they have at different times done much damage to vessels of a lighter draught."

Operations at Hell Gate to improve the navigation by blasting rocks, from August, 1851, to December, 1853, under the superintendence of the late E. Merrian, esq., and subsequently of the late Major Fraser, corps of engineers.

Mr. Merrian, in his letter of the 22d of December, 1852, to General Totten, chief engineer United States army, states: "When M. Maillefert commenced firing on Pot rock the 19th August, 1851, there was but eight feet of water upon it. On the 3d of September Lieutenant Bartlett made an examination of that rock, by which it appeared that the rock had been reduced four and a half feet by 16 charges. On the 18th October Lieutenant Bartlett addressed a letter, the original draft of which was by him (*i. e.* Maillefert) handed over to me, in which he stated that M. Maillefert had reduced Pot rock to 16 feet, mean low water. At that date M. Maillefert had fired 85 charges on Pot rock.

"On the 2d and 3d of January, 1852, he (*i. e.* Lieutenant Bartlett) again surveyed Pot rock, and stated, officially, that there was 19 feet of water on Pot rock. Up to that date 234 charges had been fired on that rock. On the 27th March, 1852, Lieutenant Bartlett addressed to me a letter from Washington, in which he stated that he had made a survey of Pot rock on the 15th of that month, and found not less than 20½ feet of water upon it at the shoalest part; and that it had been reduced from 225 feet length to 172 feet length, and from 60 feet width to 40 feet width.

"From the recommencement of operations in February to the date of this survey there had been 50 charges fired on Pot rock, making 284 charges from the commencement.

"It seemed reasonable to suppose, if the water on Pot rock had been increased from 8 to 20½ feet, and the length reduced from 225 to 172 feet, and its width reduced from 60 to 40 feet, by 284 charges, that 200 additional charges would complete its reduction to the depth of 24 feet; hence my estimate of September 17, 1852."

Mr. Merrian, in his statement of operations on the rocks of Hell Gate and East river, submitted to the Committee on Naval Affairs of the United States Senate, August, 1852, gives the following:

RECAPITULATION.

Name.	Charges.	Pounds of powder.	Cost.	Rock removed.
Pot Rock	284	34,231	$6,837 30	12½ feet.
Frying Pan	105	12,387	2,116 81	9½ feet.
Way's reef	135	15,549	2,543 66	9½ feet.
Shelldrake	6	750	110 34	8½ feet.
Baldheaded Billy	1	125	500 00	Entirely.
Hoyt's Rocks	8	1,000	250 00	Entirely.
Diamond reef	78	9,750	1,434 42	2 feet.
Hallet's Point	3	400	69 06	No results.
Total	620	74,192	13,861 59	

In the same paper he gives the following record of the depth of water upon the rock prior to the commencement of his operations, and at the close thereof:

Name.	Original depth.	Depth at close of operations.
	Feet.	*Feet.*
Pot Rock	8	20½
Frying Pan	9	18½
Way's reef	5	14½
Shelldrake	8	16½
Diamond reef	16	18

This reported increase of depth due to blasting will be found exaggerated, though without fault of Mr. Merriam, who was deceived by the official reports of the surveys. He is, on the contrary, entitled to great credit for the results actually attained, and for the arduous and efficient services which he gratuitously rendered to further an important public improvement.

Congress, in 1852, having made an appropriation of $20,000 for the removal of rocks at Hell Gate, this operation fell under the charge of the engineer department, and Major Fraser, corps of engineers, was assigned to the duty. Major Fraser presented his preliminary estimates, based upon the depths given above. But immediately after having surveyed Pot Rock he reports, October 22, that instead of there being 20½ feet there was actually but a little over 18 feet of water upon the rock. This discovery showed a much diminished quantity of work done, and indicated a large increase of his previous estimate.

He recommended the removal of the following rocks: Pot Rock, Frying Pan, Way's reef, the rock near Woolsey's bath-house, certain loose rocks near the shore, a part of Hallet's Point, and certain sharp points at Negro head, in the middle channel. On November 10, 1852, Major Fraser reports Pot Rock to be, at the 24-foot curve, 220 feet in length, and 63 feet across at the widest part. His survey of June 28 and 29, 1853, shows a minimum depth on the rock of 21 feet 4 inches at low water, as the result of firing 800 charges, at a cost of $14,963 03. It is quite likely that 100 charges were subsequently fired, though no certain record can be found, and that $18,000 nearly was devoted to blasting on Pot Rock.

In July, 1853, Major Fraser estimated the cost of removal of one cubic foot of rock at $1 14. Several of his reports during the fall of 1853, and the sketch of his survey in October of that year, appear to have been lost.

The method pursued under the superintendence of Mr. Merriam and Major Frazer excluded the employment of diving-bells or submarine armor, and the charges of powder were consequently placed in position without that examination of the bottom which would have developed in each charge its full useful effect. The work was finally suspended for want of funds, and since 1852 no appropriation has been made by Congress for the removal of these obstructions.

The advisory council to the "commissioners relative to the encroachments and preservation of the harbor of New York," consisting of General Totten, chief engineer United States army, A. D. Bache, superintendent United States Coast Survey, and Commander Charles Henry

Davis, United States navy, made to that body September 30, 1856, an important report upon the improvement of the navigation of Hell Gate passage, which is to be found on page 197 of the reports of the New York harbor commission of 1857, republished by order of the Chamber of Commerce. A thorough survey of this channel was made by Lieutenant Commanding Craven, assistant Coast Survey, and a current chart prepared to illustrate their report. The advisory council recommends the removal by blasting of Pot Rock, Frying Pan, Way's reef, a portion of Hallet's Point, and other rocks of minor consequence. Baldheaded Billy, Blackwell's Rock, a rock near Negro Point, two east of Woolsey's bath-house, and one to the southward of that building. The council likewise recommends the closing of the small channel between the Bread and Cheese and the head of Blackwell's island, the building of stone piers, with spring fenders, on Hog's Back, the Gridiron, and Bread and Cheese, and the erection of a beacon on Rylander's reef.

The report of Lieutenants Commanding C. H. Davis and D. D. Porter, and of the advisory council, together with the notes and extracts taken therefrom, furnish a full catalogue of the dangers and obstructions to this navigation, and it is not thought necessary to dwell longer upon this branch of the subject.

During the present season surveys and examinations of Hallet's Point, Scaly Rock, the Frying Pan, and Pot Rock have been made, and the results given in the sketches herewith. An examination was likewise made by divers of the surfaces of Pot Rock and Frying Pan, principally with the view of ascertaining the feasibility of blasting by placing the charges upon the rock, and although nothing special has been elicited, the indications are that some of the blasting necessary to be done can be effected by simply placing the charge in contact with the rock.

Work projected for the improvement of the channel of Hell Gate.

This portion of the subject has so frequently been discussed by officers of distinguished ability, whose reports are published, that little further remains to be said. It is agreed that certain rocks in the channel, viz: Pot Rock, Frying Pan, Way's reef, Shelldrake, and others nearer shore, viz: the rock of Negro Point, those near Woolsey's bath-house, Blackwell's Rock, together with portions of Hallet's Point and of Scaley Rock, should be removed. Sea-walls have been likewise recommended to be built on the Gridiron, Hog's Back, and on the Bread and Cheese, and a stone beacon to be placed on Rylander's reef.

To the rocks to be removed may be added the Heeltap Rocks, situated off the end of Great Mill Rocks, which by their position compel vessels to make such a circuit as to endanger their safe passage past Rylander's reef. To the sea-walls may be added one upon Rylander's reef and another along the 17-foot curve of Great Mill Rock, on the side of the middle channel, to mark the passage and to sheer off vessels.

The great reefs in the middle of pass—Flood Rock, Negro Head, the Gridiron, and Great and Little Mill Rocks—have been little noticed in any scheme of improvement, notwithstanding they form the greatest obstacle to the pass of Hell Gate being converted into a highway for commerce. In the existing state of the art of removing rock under water, the imagination was appalled at the notion even of meddling with such means.

The middle channel is narrow, and is rendered dangerous by the projection of Negro Head into its lower outlet. The least improvement that can be recommended in this report should include Negro Head, and the increase of the width of this channel to about 340 feet, as marked on the map sent herewith.

Estimates are submitted for three projects.

The first includes the removal of all rocks mentioned at the beginning of this division of the report, with the construction of the sea-walls, and likewise provides for the improvement of the middle channel and the removal of Negro Head.

The second includes the cost, likewise, of the removal of that part of the middle reef known as Negro Head, Hen and Chickens, Flood Rock, and Gridiron, thus throwing the eastern and middle channels into one.

The third includes the smaller rocks and the sea walls, and makes no provision for improving the middle channel or otherwise interfering with the middle reef.

With every improvement of Hell Gate the number of vessels passing through will increase, and the necessity for further room will become more apparent.

Hell Gate now washes with its waters the corporate limits of the city; before many years it will form a portion of the busy harbor of New York, and then will there arise a demand for improvement to an extent which has not yet in idea even been entertained.

The uncertainty and slowness attending blasting under water has had the effect of diverting public attention from that consideration of Hell Gate to which the importance of the improvement is really entitled; and it is believed, as soon as the work can be pushed in a regular manner subject to fixed laws of calculation, like blasting on land, that the extent of improvement needed for the interests of commerce will be the sole limit to public effort in this direction.

What extent of work is really demanded now for the future is a problem which more properly belongs for solution to those representing the interests of commerce in this city, owing to their more perfect acquaintance with its wants and capacity. This report does not prescribe these limits, but the estimates, tables, and other information here furnished will enable any one to calculate the expense of projects different from those formally set forth.

Estimates for 24 and 26 feet depth at mean low water are separately made in each project.

To W. S. Edwards, esq., assistant in the Coast Survey, I am indebted for surveys of Pot Rock, Frying Pan, and the Heeltap Rocks, made under circumstances of difficulty; and to G. W. Blunt, commissioner of pilotage, for reliable information in this and other cases for the benefit of the harbor.

MODE OF CONDUCTING OPERATIONS.

The quantity of work to be done, and the consequent cost as shown in the estimates, are so great as to demand, before embarking largely into it, that a project for the operations not only reasonable in itself, but subjected to fixed laws of calculations, should be presented; but before entering upon this subject it would be well to discuss the process already employed, and ascertain if possible what the results have been.

The improvements of Hell Gate were made by exploding charges of powder placed upon the rock, no advantage being taken of submarine apparatus of any kind to establish these charges where the greatest effects might result. So long as the rock was found in isolated or separate pinnacles, this process, imperfect as it was, produced great effects. But when the projecting points were knocked away and the solid bed of rock reached, progress became slow and doubtful and the cost great. The small amount of appropriation granted by Congress having been exhausted, the work has since been left in this unsatisfactory state.

The rock blasted was supposed to have been blown into deep water by the force of the charge, since there was no provision made for its removal by other means; but it is evident that such results became very problematical when the area of the rock is increased and the distance to which the fragments should be moved increased.

No reliable estimate could be framed upon such a process, even if it were sure to be attended with final success, which is more than doubtful.

The employment of divers, which the small amount appropriated for this improvement did not justify, would have had a result more satisfactory and perhaps have furnished data for calculation. As it is, for this particular locality no additions to our previous knowledge have been gained. The project presented in this report consists in first preparing the surface for ulterior operations by blowing off the sharp points and projections by charges placed in position by divers, until the rock is reduced to a more uniform surface, then to blast the rock by introducing charges into drill-holes made for the purpose, and to remove the debris by divers.

The current, which has a maximum velocity of 8.50 miles, limits the time of working under water to a little over two hours per day, during and about the time of slack water, and hence the time and expense, unless some means of shielding the divers and operators from the force of the current can be devised, would prove a serious objection.

Even if the persons using the drill were protected from the current, the delay incident to this mode of operations would be considerable; but if the drilling were conducted from the surface of a platform above the water, the same results would be reached as on dry land.

A platform of suitable size, with vertical sliding supports capable of being raised or lowered through a convenient height, is prepared and floated to its position, supported on the decks of two scows or other floats, one on each side. Arrived at the place the floats are moored, the vertical supports of the platform let down to the bottom, securely fastened to the platform, and braced to each other if necessary. This operation being done at the top of the tide, the scows are floated away when the water falls. The supports to the platform may be placed within 10 feet of each other, and the weight of the platform, to insure steadiness and stability, fixed at any desirable standard.

The supports may be lashed above and below the platform to the uprights placed for that purpose, and may be wedged also, to prevent working.

To avoid the interference of the currents with the drills, these may be made to work in hollow iron cylinders reaching from the platform to the rocks.

A steam-engine or machine worked by hand can then be applied to the drills, and the work pushed regardless of the currents.

To remove the rock blasted it will likewise be necessary to protect the persons of the divers from the force of the currents, and it is proposed to do this in the following or similar mode:

Two cylindrical floats, of sufficient buoyancy, made of boiler iron, are placed say 30 feet from center to center. Towards their extremities they are inclined towards each other until they meet, forming one float, say 160 feet long and 40 wide. Curtains of iron, extending along the whole outer line of the floats, are permanently fastened at their upper lines to those floats, the lower end of the curtain being attached by falls to davits or small derricks upon the floats, so as to be lowered or raised at will. These curtains are separated into lengths of about 20 feet, that each may be managed independently of the other.

The curtains should be flexible, and may be made of plates of iron,

say one foot wide and 20 long, connected with those in contact by hinge joints.

The floats being placed in position and moored securely, the curtains, by sections, are let down to the bottom, their extra depth allowing an extent of several plates to rest upon the rock. An interior space of 160 feet by 40 on the bottom is thus protected, where the divers can fill the buckets, which are afterwards raised and emptied into scows with valve bottoms, lying alongside. The debris is then towed away and deposited where desirable.

There is nothing in these expedients which suggests practical difficulties which skill could not surmount, and confidence is felt that these or similar contrivances can be relied upon to solve this problem. Before work is really undertaken, trials should be made and prosecuted until a good result is obtained. There is no doubt felt that the obstacle in the way, viz., the force of the current, can be neutralized, and it remains only to decide whether the object is worth the money it will cost, a question which it is the privilege of others to determine.

DATA FOR THE ESTIMATE.

The rock in the samples obtained contains an excess of mica, making it soft to the drill. The drill is supposed to bore seven feet a day, though it may average 10 feet. The estimated cost of drilling includes mooring and arranging the platform, services of men attending, of blacksmiths, sharpening tools, steel expended, services of engineer and fireman, coal used in the smithery and for the engine, services of divers in arranging the supports of the platform and placing the drilling tubes, labor of unmooring platform, &c. Estimated cost per lineal foot, $4.

The cost of each charge includes the estimated cost of drilling the rock, of the canister and charge, labor of divers in placing the charge, services of the operator, and boat's crew in firing, expense of wires, &c. The small charges are first placed in the holes and split up the rock; the larger charges are introduced into the crevices and seams thus formed, and complete the work of breaking up the mass.

Estimate for 50-pound charge of gunpowder $45 80, drilling included; estimate for 150-pound charge of gunpowder $41 75; estimate for 5-pound charge nitro-glycerine $43 64, drilling included; estimate for 15-pound charge nitro-glycerine $35 35; estimate for $3\frac{1}{13}$-pound charge nitro-glycerine $41 63, drilling included; estimate for $11\frac{7}{13}$-pound charge nitro-glycerine $29 29. The sea wall on the Gridiron is intended to be of large cut blocks, regularly coursed. The top is to be four feet above highest water. The general height is 23 feet, at certain points 28 feet, and its thickness is 10 feet. Some of the rock taken from the channel should be deposited behind the wall to the level of low water to form a backing; this can be done without extra expense. The portion of wall to be laid under water is first inclosed by a coffer work of wood, not water-tight, intended solely to protect the divers from the force of the current. This expense is included in the estimate, as well as that of forming a bed for the foundation. The supposed cost will be $80 per cubic yard. The expense of this construction should limit its employment to the most important cases.

The rubble sea-walls are composed of stone thrown in loosely to the level of low water, but above that to the top, four feet above highest water, a dry wall of split uncut blocks is supposed to be laid by hand. The loose rubble foundation is 12 feet wide at the top, and the slope to the bottom is supposed to be one to one and a half or two. The super-

structure is 10 feet thick and 11 feet high. The estimated cost is $4 50 per cubic yard for the rubble, and $24 for the superstructure.

A large estimate is necessary for machinery, including scows, boats, anchors, chains, cordage, and liberal allowance for losses, wear and tear, arising from the peculiar nature of the service required. Accidents from collisions and consequent repairs, incident to the strong currents and the number of passing vessels, will probably be frequent and should be kept in view. In this estimate every machine, scow, or boat is intended for a clearly defined service. The cost from this estimate of blasting and removing each cubic foot of rock is $1 64. Major Fraser, in 1853, from the results of the process of removal used by him, found the cost then to be $1 14 per foot, which at present rates would be at least $1 71. But Major Fraser expended nothing for removing the rock by hand, the charge of powder being supposed to do that.

The estimate is therefore not in excess, and is kept to this low limit by the contemplated use of the proper machinery.

TABLE.

Subject.	To a depth of 26 feet at mean low water.	To a depth of 24 feet at mean low water.
Estimated cost of first project	$5,723,129 15	$5,008,579 95
Amount saved by using drill, boring into rock at the rate of one inch per minute, including cost of one drilling platform, which might be dispensed with	*51,014 00	*48,536 00
Amount saved by using nitro-glycerine instead of gunpowder, when its explosive force is estimated at ten times that of the latter	†76,430 80	†65,502 00
Amount saved by using nitro-glycerine instead of gunpowder, when its explosive force is estimated at 13 times that of the latter	‡141,745 37	‡122,075 30

* Or less than one per cent. † Or one and three-tenths per cent. ‡ Or less than two and a half per cent.

The small proportion which an improved process of drilling the rock, or the use of a more powerful explosive agent, will save in the cost, may surprise many; but the cause is evident, viz: the small proportion of the cost of the whole blasting process to that of the other items of the project.

The table likewise shows that as a question of cost this improvement is independent of any particular form of improved machinery for drilling, or special explosive agent, leaving to the government full liberty of choice in these respects. For the sake of the men employed upon such works, no compound should be used which is liable to explode spontaneously, or from causes beyond the control of ordinary carefulness.

Certain conclusions may here be concisely stated:

1. Any reasonable hope of effecting this improvement depends upon the rejection of misty and fanciful schemes, which cannot be brought within the rules of ordinary calculation. This report has attempted one method of solution, and it is hoped many better may be found.

2. It was necessary, in framing the estimate, to make just and liberal allowances, and to provide for contingencies and accidents attending operations not only difficult in themselves, but also little assisted by data derived from any source. On the other hand, there is no doubt

hat a serious and well-considered attempt to push the work will be the ıeans of stimulating mechanical inventions suited to this end, which, ;ith the experience gained from day to day, will not only expedite the ırogress, but also materially diminish the cost, especially in the large tem of removing the rock.

3. The precise depth to be attained will be dependent not only upon he present, but upon the future draught of vessels. On this point it ıust be considered that this is the only channel leading to New York ;here additional depth could be gained, and a liberal standard in fixing his would be best, since, if error be committed in the opposite extreme, he cost of remedy would nearly if not quite equal that of the first ıperation.

4. A re-survey of the rocks obstructing the passage, to fix their pre-ise outlines, is very necessary. The Coast Survey office intend to begin his, it is understood, in the spring. A marked difference in the char-ıcter of Frying Pan and Heeltap rocks may be seen by comparing the ;eneral map sent herewith with the last partial surveys of Mr. W. S. Edwards, assistant Coast Survey. A modification of the position of the wall on Hog's Back and Holmes's Rock may result from a new examina-ion.

Respectfully submitted.

JOHN NEWTON,
Lt. Col. Engineers and Brevet Major General U. S. A.

Brevet Major General A. A. HUMPHREYS,
Chief of Engineers U. S. Army, Washington, D. C.

Table showing quantities of rock to be blasted and removed from certain localities, &c.

Locality.	Blast holes.	Lineal feet of drilling.	Pounds of powder.	Number of powder cans.	Pounds of steel.	Area, square feet.	Rocks removed, cubic feet.
Depth increased to 26 ft., mean low water.							
Pot Rock	152	1,064	41,850	387	320	12,125	33,500
Frying Pan	180	1,240	48,450	443	372	12,475	51,675
Way's reef and Shelldrake	101	707	27,850	253	212	6,200	44,200
Heeltap	285	1,896	74,250	685	569	23,000	53,000
Negro Head and Middle channel	3,248	22,736	893,200	8,120	6,821	276,800	1,456,400
Rock off Negro Point	21	144	5,550	51	43	1,400	7,700
Scaly Rock	121	847	33,350	303	254	8,500	49,300
Hallet's Point	1,399	9,790	369,950	3,399	2,937	73,800	841,030
Hen and Chicken, Flood Rock, Gridiron, Negro Head, and Middle channel	6,808	47,656	1,914,000	17,296	14,296	426,800	4,272,000
Depth increased to 24 ft., mean low water.							
Pot Rock	152	1,064	40,000	368	320	10,000	10,971
Frying Pan	120	840	30,000	280	252	9,000	30,000
Way's reef and Shelldrake	101	707	27,850	253	212	6,200	31,800
Heeltap	114	800	28,200	264	240	9,000	29,500
Negro Head and Middle channel	2,240	15,680	724,000	6,320	4,704	196,000	994,000
Rock off Negro Point*	.....	.....	.....	.....	.....	.....	.....
Scaly Rock†	.....	.....	.....	.....	.....	.....	.....
Hallet's Point	1,399	9,790	369,650	3,399	2,937	73,000	775,330
Hen and Chicken, Flood Rock, Gridiron, Negro Head, and Middle channel	5,800	40,600	1,595,200	14,500	12,180	322,000	3,515,600

* To obtain a depth of 20 feet at mean low water. † To cut off its projection into the channel.

Estimate.

Designation of work and materials.	To secure a depth of 26 feet at mean low water.	To secure a depth of 25 feet at mean low water.
FIRST PROJECT—SIX YEARS' OPERATIONS.		
Blasting and removing rock, viz: Pot Rock, Frying Pan, Way's reef, Shelldrake, Heeltap, rock off Negro Point, Scaly Rock, and Hallet's Point—		
2,259 50-pound charges, at $45 80	$103,462 20	.....
4,661 150-pound charges, at $41 75	194,596 75	.....
2,028 50-pound charges, at $45 80	.....	$92,882 40
4,289 150-pound charges, at $41 75	.....	179,065 75
Removing 1,080,405 cubic feet, at $1	1,080,405 00	.....
Removing 934,601 cubic feet, at $1	.....	934,601 00
Blasting and removing rock, viz., Negro Head, and deepening and increasing the width of the middle channel—		
3,248 50-pound charges, at $45 80	148,758 40	.....
4,872 150-pound charges, at $41 75	208,406 00	.....
2,240 50-pound charges, at $45 80	.....	102,590 00
4,080 150-pound charges, at $41 75	.....	169,340 00
Removing 1,456,400 cubic feet, at $1	1,456,400 00	.....
Removing 994,000 cubic feet, at $1	.....	994,000 00
Sea-wall of cut-stone along the Hen and Chicken, Flood Rock, and the Gridiron, including preparing bed for foundations, and breakwater of wood to protect the workmen from the force of the currents, 1,140 feet long, 10 feet wide, 20 to 28 feet high, top 4 feet above high water, viz:		
10,000 cubic yards, at $80	800,000 00	800,000 00
Rubble sea-wall, finished on top with large blocks laid by hand, 750 feet long, along the 12-feet curve of Hog's Back and Holmes's Rock, viz:		
10,056 cubic yards of dry rubble, at $4 50	45,252 00	45,252 00
3,052.5 cubic yards of stone masonry, at $24	73,260 00	73,260 00
Rubble sea-wall, as before, along the 17-feet curve of Great and Little Mill Rocks next the middle channel, 450 feet long, viz:		
15,66. cubic yards of dry rubble, at $4 50	70,470 00	70,470 00
1,831.5 cubic yards of stone masonry, at $24	43,956 00	43,956 00
Rubble dike, as above, closing the channel between Bread and Cheese and the end of Blackwell's island, 250 feet long, viz:		
2,250 cubic yards of dry rubble, at $4 50	9,990 00	9,990 00
1,017.5 cubic yards of stone masonry, at $24	24,420 00	24,420 00
Rubble sea-wall, as above, along the 12-feet curve of Bread and Cheese, 210 feet long, viz:		
2,952.6 cubic yards of dry rubble, at $4 50	13,286 70	13,286 70
854.7 cubic yards of stone masonry, at $24	20,512 80	20,512 80
Rubble sea wall, as above, along the 12-feet curve of Rylander's reef, 210 feet long, viz:		
3,729 cubic yards of dry rubble, at $4 50	16,780 50	16,780 50
854.7 cubic yards of stone masonry, at $24	20,512 80	20,512 80
MACHINERY.		
One iron floating current-breaker, 160 feet long	150,000 00	150,000 00
One iron floating current-breaker, 100 feet long	110,000 00	110,000 00
Two floating derricks	30,000 00	30,000 00
One scow, with 50 feet mast and hoisting gear	5,000 00	5,000 00
Six scows, 60 feet long	18,000 00	18,000 00
Two scows, each 60 feet long, with valve bottoms	7,000 00	7,000 00
Sixteen scows, each 30 feet long	35,200 00	35,200 00
Six small boats	1,800 00	1,800 00
Two drilling platforms	80,000 00	80,000 00
Anchors, chains, buoys, hawsers, tow-lines, fasts, falls, and lashings	37,000 00	37,000 00

Estimate—Continued.

Designation of work and materials.		To secure a depth of 26 feet at mean low water.	To secure a depth of 25 feet at mean low water.
MACHINERY—Continued.			
ɔpairs of machinery, due to wear and tear and collisions with vessels, loss of anchors and chains, and replacement of rope, for six years' service, being about 60 per cent. of the prime cost		$281,400 00	$281,400 00
CONTINGENT AND GENERAL SERVICE.			
ʍo clerks, at $130 each	$3,120 per annum.		
ʍo draughtsmen, at $130 each	3,120 do		
ıe messenger, at $60	720 do		
ɛnt of office	1,500 do		
ɛpenses of office	1,200 do		
ʍo chief divers, at $380 each	7,600 ten months.		
ıe master mason, at $150	1,800 do		
ıe overseer of laborers, at $120	1,440 do		
ıe master blacksmith, at $120	1,440 do		
ıe master carpenter, at $120	1,440 do		
ıe rigger, at $100	1,200 do		
ıe storekeeper, at $120	1,440 do		
ɔur sub-overseers, at $60 each	2,880 do		
x night-watchmen, at $50 each	3,600 do		
ɔrty laborers	18,960 do		
ıree tugs, at $50 per day	33,000 do		
	84,460 six years =	506,760 00	506,760 00
ɐase of ground for storehouses		25,000 00	25,000 00
ɔnstruction of wharf and repairs		42,000 00	42,000 00
harf derrick		3,500 00	3,500 00
ɔnstruction of storehouses, magazines, &c		15,000 00	15,000 00
asting and removing certain small rocks, viz: Bald-headed Billy, Blackwell's Rock, rocks near Woolsey's bath-house		50,000 00	50,000 00
Total for improvement by first project		5,723,129 15	5,008,579 95
SECOND PROJECT—TEN YEARS' OPERATIONS.			
ɔtal for improvement by first project		5,723,129 15	5,008,579 95
ld to amount of first project the cost of removing Negro Head, Flood Rock, Hen and Chicken, and the Gridiron, increased by extra repairs and replacement of machinery and increased contingent services for ten instead of six years, and diminished by cost of removing Negro Head and improving the middle channel, and of cut-stone sea-wall designed for the Gridiron, viz., amount to be added		2,769,516 00	2,729,395 00
Total for improvement		8,692,645 15	7,737,974 95
THIRD PROJECT—FOUR YEARS' OPERATIONS.			
nitting all improvement of the middle channel, with corresponding diminution of cost, and decreased wear and tear of machinery and of contingent services, viz., amount ɔo be deducted from the cost of first project		2,876,324 40	2,333,650 00
Total for improvement		2,846,804 75	2,674,929 95

JOHN NEWTON,
Lieutenant Colonel of Engineers, Brevet Major General U. S. A.

O 5.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., March 5, 1868.

SIR: The resolution of the Senate of the United States of the 4th ultimo, requesting the Secretary of War "to communicate to the Senate an estimate of the expense of removing the three reefs known as Battery reef, Diamond reef, and Coènties reef, in the East river, New York harbor," referred to these headquarters for report, is herewith returned, with a copy of the report of Lieutenant Colonel and Brevet Major General John Newton, corps of engineers, to whom the matter was intrusted. His views are concurred in.

The estimated cost of removal of the reefs in question is as follows, viz:

For their removal to a depth of 24 feet	$463,145 00
For their removal to a depth of 22½ feet	299,370 00

Attention is invited to the letter from these headquarters of this date in relation to the removal of obstructions from Hell Gate, and it is suggested, in order that the necessary machinery may be applied to all the works, that a general appropriation be made (to be expended upon each of the obstructions in such order as circumstances may require) for the first year, of $500,000.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, commanding.

Hon. E. M. STANTON,
Secretary of War.

O 6.

UNITED STATES ENGINEER OFFICE,
395 *Canal Street, New York, March* 2, 1868.

GENERAL: Having been required to make estimates for the removal of Battery reef, Diamond reef, and Coenties reef, I have the honor to submit the following report:

BATTERY REEF.

This reef is in reality a shoal formed of successive deposits from the currents. The existence of rock, except in the form of ballast stone thrown overboard, has not been determined. As it was not contemplated to make surveys and observations at this time, I have simply to avail myself of the results of those already furnished.

The published comparative chart of the lines of 1837 and 1855 shows during this interval a considerable advance of the 18 and 24 feet curves into the channel within limits included between Castle Garden and Whitehall. This projection of the shoal seems to be coincident with the erection of a rubble wall nearly in the line of the present Battery wall.

The published comparative chart of 1855 and 1859, during which interval the Battery extension attained considerable development, shows no general advance of the 18 and 24 feet curves into the channel, though there was a considerable deposit during this period, particularly in the re-entering between Pier No. 1, North river, and the branch of the 18-foot curve just south of Castle Garden.

The comparative chart of 1859 and 1867, during which interval the Battery extension had been virtually completed, shows no increase of the shoal channelwards, except a small salient projection of the 24 and 18 feet curves of the shoal of 1867 beyond the corresponding curves of the former date.

The comparison, however, shows a general receding of the 24, 18, and 12 feet curves of 1867, a diminution of the size of the shoal, and a general increase of its depth, indicating a favorable current action and a gradual return to the state of things existing before the Battery extension was inaugurated. The survey of 1867 does not embrace the space between Castle Garden and Pier No. 1, and therefore the change, if any, in this re-entering angle is not known. The comparative chart of 1859 and 1867 is sent herewith.

The Battery shoal is due, primarily, to the meeting at this point of the ebb currents, and to the dividing of the flood currents of the East and North rivers; secondly, in my opinion, to the great projection of Pier No. 1, North river, beyond the line of shore; and thirdly, to the Battery extension, and to the careless mode of effecting it, whereby large quantities of material were washed off and deposited on the shoal. But the influence of the Battery filling, beyond a decrease of depth on the shoal and the formation of lumps, has not been materially felt in the advance of the shoal towards the channel. The indications of the survey of 1867 were favorable as to the probable effect of dredging in removing the point of the shoal. The space to be dredged lies between the projected 22 and 18 feet curves, represented on the tracing of 1867 in broken and dotted lines. It is impossible to state whether all the space dredged will ultimately be a gain, but the removal of the point of the shoal would probably be permanent.

ESTIMATE.

Dredging 37,000 cubic yards, at 35 cents	$12,950
Contingencies	1,295
Total	14,245

And a smaller sum than the above, devoted only to cutting away the outer boundary of the shoal, would likewise be beneficial.

DIAMOND REEF.

This reef, situated in the channel between Governor's island and the Battery, has, at the 24-foot curve, a length of 366 feet and a maximum width of 255 feet.

The information obtained from the various surveys and examinations is very discrepant.

The last examination, in 1867, made for the Chamber of Commerce, limits the amount to be removed mainly to three comparatively small lumps in the reef, upon which the minimum depth at low water is 18 feet.

Of the Coast Survey charts of this reef, that of Lieutenant Commanding Craven of 1855 is the most elaborate and detailed, and is entitled, for these reasons, to superior consideration for the purposes of this estimate.

M. Maillefert fired upon this reef 74 charges, at an expenditure of $1,400 in round numbers. His operations were suspended for want of funds, and resulted in reducing the depth of the highest portions of the

reef from 13½ feet to 18 feet at low water. The examination of 1867, if reported correctly, would prove either that an incredible quantity of work was effected by this small sum, which no one has claimed for it, or else that Lieutenant Craven's chart is entirely in error.

The examination of 1867, besides, was not carried sufficiently far—it being perfected in four hours—to present a good delineation of the reef; nor is the reduction of the soundings reliable, this having been done not by comparison with Coast Survey standard of mean low water, but by estimate.

For the above reasons, and for want of more recent and detailed surveys, I am compelled for the purposes of this estimate to rely upon the general correctness of Lieutenant Craven's survey, but have supposed that the minimum depth at low water was not less than 20 feet.

This supposition would more than compensate for any portions removed by previous blasting.

Two separate estimates are made, one for removal to a depth of 24 feet at mean low water, the other to a depth of 22 feet low water at spring tides, corresponding nearly to 22½ feet at mean low water.

It is a serious question whether any portion of the harbor in mid-channel should have a less depth than 24 feet at mean low water, whether the present demands of commerce actually require it or not.

The area of rock to be removed, included within the 24-foot curve, is 57,700 square feet, and within the 22½-foot curve, 45,800 square feet. The quantities of rock to be removed corresponding to these depths are, respectively, 157,400 and 74,050 cubic feet.

COENTIES REEF.

This reef is 600 feet from Coenties slip pier. Work was undertaken on it by the New York Submarine Engineering Company in 1861 and 1863, under contract with the New York city authorities, until it was finally suspended, owing principally, as alleged, to continual losses and accidents due to collisions from passing vessels.

I have obtained from Mr. Thomas Bland, the secretary of the company, a sketch showing the amount of work done, and this quantity, as closely as it could be ascertained, is deducted from that which was obtained from Lieutenant Craven's chart.

This reef is 250 feet long and 130 wide. The area to be removed at the 24-foot curve is 19,000 square feet, and at the 22½-foot curve, 12,400. The quantity of rock would be, respectively, 56,900 and 31,900 cubic feet.

I decidedly recommend, as in the case of Diamond reef, that it be excavated to a depth of 24 feet at mean low water.

The removal of both Diamond and Coenties reef I consider of great importance to the harbor of New York.

The surveys of Lieutenant Craven, which were primarily intended for purposes of navigation, and fully adequate to the end in view, are not however specially suited to the object of determining the shape and contents of the rock to be removed, and I recommend, before work be commenced, that another survey be made. The results of this may be important in modifying the estimates drawn from the present sources of information, or at least in clearing up doubts as to the correctness of the quantities assumed.

The experience of the company who operated upon Coenties reef has been to demonstrate the necessity of a suitable protection against collisions with passing vessels for the men at work. The company used large booms, framed in the shape of a lozenge, and to include the space ope-

rated upon; but this device was found to be entirely insufficient for the security of life and property.

As a part of the estimate, therefore, it will be necessary to provide for the cost of such protection, which in the simplest form would appear to be four strong barges or hulks, moored to surround the desired space.

This outlay, which would answer for both reefs, may amount to between $35,000 and $40,000.

ESTIMATE—DIAMOND REEF.

Removal to 24 feet mean low water, amount asked for, $309,400.

Removal to 22½ feet mean low water, $185,125.

On account of machinery, protection against collisions, and other incidental expenses, the removal of the smaller amount of rock would cost proportionally more.

COENTIES REEF.

Removal to 24 feet mean low water, amount asked for, $139,900.

Removal to 22½ feet mean low water, $100,000.

I respectfully propose, in asking for appropriations, that the amount be appropriated in gross: *i. e.*, so much for Battery shoal, Diamond reef, and Coenties reef, without naming the sum for each; and if the sum asked for Hell Gate could be included in the same general appropriation, viz., for removing aforementioned rocks and Pot Rock, Frying Pan, and Shelldrake, it would be convenient. I do not desire that the contractors should have the benefit of knowing what amounts are estimated for each part of the work.

By including the rocks at Hell Gate in one bill with the others, the machinery would be transferable from one rock to another, and the cost of preliminary trials and of valuable experience would be distributed, as it ought to be, among all, instead of being charged to one rock, as it would be in the other alternative.

Respectfully submitted.

JOHN NEWTON,
Lieut. Col. of Engineers and Brevet Major General U. S. A.

Brevet Major General A. A. HUMPHREYS,
Chief of Engineers U. S. A., commanding Corps of Engineers, Washington, D. C.

APPENDIX P.

ENGINEER OFFICE UNITED STATES ARMY,
Newport, Rhode Island, August 8, 1868.

GENERAL: In compliance with circular dated headquarters corps of engineers, Washington, D. C., June 10, 1868, I have the honor to submit the following annual report of progress on the works of river and harbor improvements in my charge for the fiscal year ending June 30, 1868.

IMPROVEMENT OF PROVIDENCE RIVER, RHODE ISLAND, OFF PAWTUXET BAR AND AT THE "CROOK."

The operations on this river have been confined for the past year to deepening and widening, by dredging, the channel at the "Crook,"

which was, previous to the dredging, a bend in the channel very inconvenient to navigation, especially as vessels are compelled to anchor in the channel.

By widening and deepening the channel vessels are able to make a direct course from the lower harbor into the river, and the anchorage ground has been considerably enlarged. Vessels are now enabled to carry 12 feet at low water up to the Fox Point wharf. The work of dredging was commenced May 10, 1867, and ended September 25, 1867. Total expenditures on this work $25,000, the amount of the appropriation, of which $2,000 was expended in raising a sunken wreck off Pawtuxet bar. In regard to future expenditures in the improvement of this river it is simply a question of widening and deepening the channel to adapt it to the growing wants of commerce. The harbor of Providence is very contracted, and inadequate to the future wants of the city. That portion of the river above Fox Point wharf, where are now the principal wharves, is narrow and shallow, although much has been done by the city within the last few years towards its improvement.

As the commerce of the place increases it will be necessary to extend the wharves to the lower harbor, where there is ample room, but owing to the shoal water new channels will have to be excavated. An annual expenditure of $10,000 could, I think, be judiciously expended in the improvement of this harbor, and would meet the requirements of commerce. This expenditure should be limited to the lower harbor, *i. e.*, below Fox Point wharf.

In regard to the points especially called for by the circular referred to, I have to report as follows:

Providence river, Rhode Island.

3. $10,000.
4. Providence district.
5. Providence, Rhode Island.
6. $164,097.
7. Same as stated in report of last year, except that the number of vessels arriving was 5,261.
8. None during the year.
9. None during the year.
10. None during the year.
11. On hand June 30, 1867..... $5,000
Cash received during fiscal year ending June 30, 1868..... 18,000

23,000

Cash expended during fiscal year ending June 30, 1868..... 23,000
Amount avilable June 30, 1868..... .....
Amount required for year ending June 30, 1870..... 10,000

IMPROVEMENT OF PAWTUCKET RIVER, RHODE ISLAND.

The operations on this river have consisted in dredging, so as to obtain a depth of six feet at mean low water.

The appropriation, $17,000, was found insufficient to complete the work, which was suspended in December last. An additional amount of $8,000, to be expended the present season, was asked for, but has not yet been received. Should nothing be done this season, it is probable

that a greater amount will be required next season, and in that case I would recommend the sum of $15,000, which can be judiciously expended. There is good reason to believe that this channel, once opened, will be maintained by the passage of propellers which are engaged in towing up and down the river.

In regard to the points specially called for by the circular, I have the honor to report as follows:

3. $15,000—provided no work is done this season.
4. Providence district.
5. Providence, Rhode Island.
6. $164,097.
7. Same as last year.
8. None during the year.
9. None during the year.
10. None during the year.

11. On hand June 30, 1867	$3,000	00
Cash received during the fiscal year ending June 30, 1868	13,900	00
	16,900	00
Cash expended during the fiscal year ending June 30, 1868	16,542	50
Balance on hand June 30, 1868	357	50
Amount in United States treasury June 30, 1868	100	00
	457	50
Amount required for year ending June 30, 1870	15,000	00

It is probable that future expenditures may be necessary to maintain the channel of this river or to increase its depth to adapt it to the increasing demands of trade, but no amount is now recommended, as the present wants will be met by the completion of the channel, and it is impossible now to say what will in future be necessary.

IMPROVEMENT OF THAMES RIVER, CONNECTICUT.

The operations on this river have consisted in dredging a channel so as to give a depth of 14 feet at high water. The original plan contemplated a channel 100 feet in width. This plan has been deviated from at the upper end of the work, just below the junction of the Shetucket and Quinnebaug rivers, the tributaries of the Thames, where the channel has been widened to 200 feet. This was found necessary in order to allow a freer flow for the waters of these streams during heavy freshets, and to prevent the accumulation of ice. In the other portions of the river it is proposed to make the channel 100 feet in width. It is expected to complete this channel the present season, and that a portion of the appropriation will be available for remedying any injuries that the channel may undergo the coming season.

In regard to the points specially called for by the circular, I have the honor to report as follows:

4. Third collection district of Connecticut.
5. New London, Connecticut.
6. $26,520 74.
7. Fully explained in report of November 19, 1866.
8. None during the year.

9. None during the year.
10. None during the year.

11. On hand June 30, 1867	$15,057 75
Cash received during fiscal year ending June 30, 1868	21,000 00
	36,057 75
Cash expended during fiscal year ending June 30, 1868	30,115 29
Balance on hand June 30, 1868	5,942 46
Amount in United States treasury June 30, 1868	45,000 00
	50,942 46
Less amount withheld, in accordance with contract for dredging, until the completion of the work	3,024 06
Amount available	47,918 40
Amount required for the year ending June 30, 1870	

REMOVAL OF MIDDLE ROCK, NEW HAVEN HARBOR, CONNECTICUT.

The work on this rock was suspended on the 21st of September, 1867, owing to the appropriation being nearly exhausted. The results of the survey were communicated to the department in my report dated January 28, 1868. To complete the removal of this rock to the depth originally proposed I have estimated $10,000. The complete removal of the obstructions at the mouth of this harbor requires not only the removal of Middle Rock, but also that of Southwest Ledge and two rocks intermediate between the two, and any plan for the improvement of the harbor should contemplate the removal of all these. On the Southwest Ledge there is six and a half feet at low water, and on the other rocks 13 and 14 feet respectively. The total amount now estimated for removing these rocks is $65,000.

In regard to the points specially called for by the circular, I have the honor to report as follows:

1. Removal by blasting to a depth of 17 feet at low water. There is now on the rock 15 feet of water.

2. Middle rock	$10,000
Southwest Ledge	30,000
Intermediate rocks	25,000
	65,000

3. $30,000.
4. New Haven district.
5. New Haven.
6. $266,111 73.

11. On hand June 30, 1867	5,937 25
Cash received during fiscal year ending June 30, 1868	
Cash expended during fiscal year ending June 30, 1868	5,686 69
Balance on hand June 30, 1868	250 56
Amount in United States treasury June 30, 1868	
Amount available	250 56
Amount required for the year ending June 30, 1870	30,000 00

WESTPORT HARBOR, CONNECTICUT.

No work has been done on the improvement of this harbor. The amount appropriated, $2,500, was found upon examination to be totally inadequate to execute the work required, and an additional amount of $10,000 was asked for.

In regard to the points specially called for by the circular, I have the honor to report as follows:

2. $10,000.
3. $10,000.
4. Fairfield district, Connecticut.
5. Bridgeport, Connecticut.
6. $47,866 07.
11. On hand June 30, 1867.....

Cash received during the fiscal year ending June 30, 1868....	$950 00
Cash expended during fiscal year ending June 30, 1868....	339 34
Balance on hand June 30, 1868.....	610 66
Amount in United States treasury June 30, 1868.....	1,550 00
Amount available.....	2,160 66
Amount required for year ending June 30, 1870.....	10,000 00

Abstract of proposals for improvement of Westport harbor, Connecticut, during the year ending June 30, 1868.

For removing rocks from channel of Saugatuck river:

D. L. Schofield, for removal of three rocks, $300.
F. J. Merryman, for removal of seven rocks, $4,500.
F. J. Merryman, for removal of seven rocks, at $125 per day.
George W. Townsend, for removal of three rocks, $1,400.
Eli Bradley, for removal of six rocks, $300.

For repairs of breakwater at Cedar Point, on Saugatuck river, Connecticut:

William S. Knowlton, for construction of wall, $18 per cubic yard.
D. L. Schofield, for construction of wall, $25 per cubic yard.
William S. Knowlton, for excavation for wall, 30 cents per cubic yard.

D. C. HOUSTON,
Major Engineers, Brevet Colonel.

SURVEY AT BLOCK ISLAND, RHODE ISLAND.

A survey of this island was made last season, and the results were reported to the department in my report of January 15, 1868.

In regard to the points specially called for in the circular, I have the honor to report as follows:

1. Survey and project of breakwater forwarded with my report of January 15, 1868.
2. $1,500,000.
3. $300,000.
4. Twenty-ninth collection district.
5. Newport, Rhode Island.
6. $14,080,32.
7. The entire coasting trade north of the Delaware, and all vessels

bound to or from New York city, would, to a greater or less extent, be benefited by a harbor of refuge at this point.

11. Cost of survey, $1,138 72.

SURVEY OF CONNECTICUT RIVER FROM HARTFORD TO ITS MOUTH.

This survey was completed last season, and the results reported in my letter to the department dated January 11, 1868.

In regard to the points specially called for by the circular, I have the honor to report as follows:

1. Deepening the channel by dredging and scraping the bars.
2. $70,000 is required to excavate a channel 200 feet wide and 8 feet deep at low water, and an annual appropriation of $10,000 to maintain it.
3. $70,000.
4. Middletown district.
5. Middletown, Connecticut.
6. $8,657 56.
7. Fully explained in my report to the department last year.
11. Cost of survey, $3,766 16.

BRIDGEPORT HARBOR, CONNECTICUT.

A few soundings were made in this harbor last season, for the purpose of ascertaining what changes, if any, had occurred since 1866. No material changes were detected.

A resurvey of the harbor is now being made, in order to determine accurately whether any changes have occurred, and to enable the proper remedy for any injuries to be devised.

In regard to the points specially called for by the circular, I have the honor to report as follows:

1. No plan has yet been devised for improving this harbor. Should anything be found necessary, it will be submitted on the completion of the survey.

I am, general, very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers, Brevet Colonel U. S. A.

Brevet Major General A. A. HUMPHREYS,
Chief of Engineers U. S. A., Commanding Corps of Engineers,
Washington, D. C.

P 1.

ENGINEER OFFICE UNITED STATES ARMY,
Newport, Rhode Island, January 28, 1868.

GENERAL: I have the honor to submit the following report of operations in removing obstructions in New Haven harbor, Connecticut, during the past season:

REMOVAL OF MIDDLE ROCK, NEW HAVEN HARBOR.

The depth of water on this rock, previous to commencing operations, was nine feet at low water. From the report in my possession I find that "a contract was made in November, 1862, with Mr. B. Maillefert, for the removal of this rock to the depth of 17 feet at low water for the amount of the appropriation, $6,000. After having fired 36

charges of powder upon it, Mr. Maillefert reported his inability to effect the reduction for the sum contracted for, and a new agreement was entered into with him to reduce the rock to the level of 13½ feet for the amount of the appropriation; this being considered to be as large an amount of work as could be effected by any other plan of operations for the same sum of money. After firing 54 charges more the contract was substantially abandoned by Mr. Maillefert, he having found that their effect was much less than he had anticipated." The plan adopted by Mr. Maillefert was by exploding charges of powder on the surface of the rock. It was estimated by the officer in charge that it would require the sum of $30,000, in addition to the $6,000 already appropriated, to remove the rock to a depth of 17 feet at low water—total cost of $36,000.

The balance of the appropriation, $5,937 25, having been transferred to me, I felt confident, after investigating the matter, that, by the aid of divers, holes might be drilled into the rock and charges exploded in them which would result in removing a considerable portion of the rock, and that the amount available would suffice to remove the rock to the depth of at least 13½ feet at low water, which was the depth required by the second contract with Mr. Maillefert.

An offer was made me by Mr. George W. Townsend to remove the rock to a depth of 13 feet at low water for $5,000, or to work by the day and accomplish what he could with the money available. Having reported this fact and my views to the engineer department, I was authorized to proceed with the work by the day. I accordingly made an arrangement with Mr. Townsend, by which he was to execute the work and furnish a vessel and crew, the necessary divers, all appliances and materials necessary for the work, at $80 per day.

The work commenced on the 13th of July and continued to the 21st of September, 1867, a total of 71 days; the total amount expended being $5,680. The rock was removed to a depth of 15 feet at low water in the shoalest place and 16 feet in the deepest, two feet more than was offered to be done for $5,000, and one and a half feet more than was required by the second contract made with Mr. Maillefert for $6,000.

There remains from one to two feet to be removed to reduce the rock to 17 feet at low water. As it becomes more difficult to remove the rock at a greater depth, owing to the fact that it spreads out and greater resistance is experienced, the cost of removing this portion will be greater than for the same depth above. Thus it is estimated that the removal of the remainder of the rock to the depth of 17 feet at low water is $10,000. Probably this amount would reduce the rock to 18 feet at low water. Only a small portion of the rock was removed from the locality, it being thrown principally over the sides of the rock. Should a greater depth be obtained, it will probably be necessary to remove some of the fragments to secure a uniform depth.

Estimating, then, $10,000 as the cost of removing the remainder of the rock, we have a total cost of removing the rock $16,000, or $20,000 less than the former estimate. Had this work been located in smooth water the work would have cost much less, but its position is very much exposed to southerly and easterly winds, so as to render it at times impossible for a vessel to lie at anchor there.

The plan pursued in removing this rock was simply by drilling holes three inches in diameter, varying in depth from three to six feet, and exploding several charges of powder in them simultaneously. The most effective explosive material used was Dr. Echall's patent chemical powder; ordinary blasting powder was also used. The rock was found to be very hard, being granite. This middle rock was found to be bold on the

to a depth of 14 feet at low water, on the basis of the work already
is as follows:

Southwest Ledge	
Rock C, (Captain Dutton's survey)	
Rock B, (Captain Dutton's survey)	
Middle Rock, what is left	

This estimate for Middle Rock varies from that submitted in annual report, which was made before the experience of last sea

The removal of the other rocks I deem of equal importance with Middle Rock. They now form a chain of dangerous obstacles to tion, stretching directly across the mouth of the harbor. The op on Middle Rock last summer, as those on Tower Rock, in Boston which were conducted by Mr. Townsend, show the feasibility of ing these dangerous obstructions at a cost trifling in comparison results obtained.

I am, general, very respectfully, your obedient servant,

D. C. HOUSTON
Major of Engineers, Brevet Colonel U.

Brevet Major General A. A. HUMPHREYS,
Commanding Corps of Engineers, Washington, D. C.

P 2.

ENGINEER OFFICE UNITED STATES ARMY
Newport, Rhode Island, June 22,

GENERAL: I have the honor to report as follows as to the ne of additional dredging in the Thames river, Connecticut, over the

it was my opinion that this amount could be expended most advantageously for the improvement of the river in giving still greater facilties to navigation, and my experience since making my estimate had convinced me that it was too low, inasmuch as I had only calculated the actual prism of earth necessary to be removed in order to obtain the requisite channel, and had omitted to consider that a given amount of material would measure less in the bed of the stream than when measured in scows, (the usual mode of measurement,) and that in order to obtain the necessary depth at every point it is unavoidable not to excavate to a greater or less extent below that depth. For these two considerations I would add 33⅓ per cent. to the estimated amount of excavation. As this additional amount was available for the improvement of the river, it was determined to extend the plan already adopted to secure a freer navigation, and to remove material which it was apprehended might, unless removed, prove of subsequent injury to the channel. I refer to the upper section above the sunken pier, referred to in previous reports. Former experience had shown that the material composing the shoal in this section had been subject to yearly changes produced by the spring freshets, and that this was owing to the narrowness of the channel, which did not allow the ice which accumulated at this point to escape without scraping on the bottom, and thus shifting the material composing the shoal. To remedy this it was determined to increase the width of the channel in this section to 200 feet, thus giving a freer outlet for freshets and the accumulated ice. Another item that was not included in my estimate is the slope on each side of the channel outside of the 100 feet which is necessary in order to allow vessels to pass. Another consists in the sunken trees which are found imbedded in the channel, and which were not detected in the survey. It is considered that these considerations will account for the necessity of additional expenditure.

The additional amount due to increase of volume, (due to mode of measurement,) and by the necessity of excavating below the depth required, is estimated at 33⅓ per cent.; the slopes on the sides of the channel, 10 per cent.; sunken trees, 5 per cent.; additional width gained in upper section, 25 per cent.; total, 73⅓ per cent.

These amounts cannot be readily determined without a resurvey, which would involve an expenditure of money to be taken from the appropriation, and not deemed necessary to show the need of further expenditures or useful in directing it.

All of the funds now available, and even more, could be expended to advantage in the improvement of this river, though it is hoped that the present wants of the commerce of Norwich will be met by the work now proposed. It is also considered that the present improvement will be permanent, as the causes which produced the present shoal water have ceased, owing to the numerous dams which have been built on the confluents of the Thames, and which must catch the greater portion of the sediment brought down by these streams.

I propose, after obtaining a channel of the requisite depth, to reserve a portion of the appropriation until the ensuing season for the purpose of remedying any possible injury that may arise from the spring freshets. If this should not be found necessary, the balance may be advantageously expended in removing the middle ground between the new channel in the upper section, and the channel to be excavated by the railroad company along the line of the wharf they are now constructing. The map accompanying this letter illustrates this. This work, however, should not be executed until after the channel of the railroad company is made, and the future effect of the current on the shoal observed.

P 3.

ENGINEER OFFICE UNITED STATES ARMY,
Newport, Rhode Island, January 11, 1

GENERAL: I have the honor to submit herewith a report of a s
of the Connecticut river between Hartford and the mouth, with
to its improvement, executed during the past season by Mr. Th
Ellis, assistant engineer.

This survey was commenced in August last, and the field oper
continued until about the 1st of November.

At the time of the commencement of the survey no correct m
the river could be found, and no accurate information could be ob
in regard to it. It was known that there were several bars in the
between Hartford and Middletown, which were serious obstructio
navigation. Attempts had been made to improve the channel
river by constructing stone piers from the banks, so as to confi
water to the channel, it being supposed that the increased scouring
of the current would maintain the desired depth of water; but
river runs through an alluvial region, and is subject to frequent
freshets, (the greatest one on record being 30 feet above low wa
Hartford,) the whole bed of the river is constantly changing, so th
the language of the accompanying report, "land formerly owned b
sons now living, lying upon one side of the river, has been passed
and now lies upon the opposite side."

Some of the piers built on one side are now on the other, others
the middle of the stream, so as to form serious obstructions to n
tion; so much so that portions of them have already been remove
others should be. Some of these piers are at present perhaps ben
to the channel, and may be left as they are, but it is probable th
some future time they may in their turn become obstacles, as the

which the river is subjected, and the consequent shifting of its bed as above mentioned, I immediately concluded that no works having in view the permanent improvement of the channel, such as piers or dikes, were admissible, if for no other reason, on account of the enormous expense of such works adequate to the purpose, not warranted by the amount of revenue derived by the general government from the navigation of the river.

There remained, then, but one plan to pursue, viz: to deepen the water on the bars by dredging, to remove obstructions, such as some of the stone piers above referred to, and some sunken trees, and in some instances driving rows of sheet-piling, as in one case immediately below the city of Hartford, where it is necessary not only to protect the banks, which are now rapidly wearing away, but to force the water into the channel. In this case it is necessary and possible, at a moderate cost, to insure a permanent channel. Having these objects in view, a survey was directed for the special purpose of determining what amount of dredging was required to furnish the desired channel, which was assumed to be eight feet at low-water mark, *i. e.*, lowest water mark recorded since 1801, the character and extent of the obstructions to be removed, and the amount of piling necessary. There being no accurate map of the river of any date, it was necessary to make a survey of the river between Hartford and Middletown for the purpose of delineating its banks. Special surveys of those points of the river requiring improvement were also directed. It would have been, and is, desirable to have a detailed survey of the bed of the river throughout the whole distance between Hartford and its mouth, as the character of the river would thus be more clearly shown, and this, I presume, might have been done under the general authority of a "survey of the Connecticut river from Hartford to its mouth;" but having in view the object of the survey, viz: the improvement of the river and the accurate delineation of the bed of the river, where the channel required improvements, the survey was confined to those points. Moreover, the season did not admit of any more extended survey, under proper supervision, than the present. Should it be deemed advisable, however, to complete the detailed survey between the points above mentioned, I would recommend it as being necessary to a full knowledge of the character of the river. It can readily be done the coming season, under the same supervision, when the present survey can be tested, and any changes that may occur be recorded. It is considered, however, that the accompanying maps and report contain all the information necessary to determine the extent and character of immediate improvements.

In connection with the survey, and for the purpose of reducing the soundings, tidal observations were made at Hartford and Middletown. A table of all the recorded freshets is embodied in the accompanying report, with a full account of the river.

Below Middletown no general survey of the river was made, the bed being generally permanent and no improvements being required, except the removal of one small rock, until we reach the mouth. The river empties directly into the sound, there being no inner bay. The mouth is very wide, and the bar which has formed by the deposit of material brought down by the freshets is constantly shifting by the action of the wind and tidal currents in Long Island sound. The distance between the channel, as shown by the Coast Survey in 1850, and that now used by steamers in crossing the bar is three-quarters of a mile. The amount of water now on the bar in the present channel is, at low water, about seven feet. A detailed examination of this bar was impracticable dur-

ing the time it was attempted, owing to rough weather, all operations on the bar being subject to the variable weather of the sound. For the present purpose, however, sufficient information has been obtained on which to base an estimate for deepening the channel to a depth of eight feet at low water, and widening it to a width of 100 feet.

It is not supposed that the improvements recommended will be of a permanent character, except in some instances, owing to the character of the river, but it is believed that if they are made it will be possible to maintain the channel obtained at a comparatively small expense. The estimated cost of the proposed improvements is $64,310—say $70,000—which amount I would respectfully recommend; and it is believed that an annual appropriation of $10,000 will be ample to maintain the channel in the river and on the bar.

At some points where the river bed is permanent, as at Hartford, it is considered that the row of sheet-piling recommended will confine the water to the present channel and keep it clear. Some of the bars do not seem to be the result of deposit, but to arise from hard material in the bed of the river, which, if once removed, will afford a permanent channel. At points where the bed of the river changes and with it the channel, it may be that it will be necessary to deepen or straighten the latter, though in some instances the channel is found to be benefited by these changes. The amount to be appropriated in future to maintain the channel, supposing the proposed improvements to be made, will also depend on the extent of the freshets in the spring. In some years little or no change may occur in the bed of the river. The information required by the act of Congress, approved March 2, 1867, (Public No. 59,) and by engineer department circular No. 11, of June 10, 1867, is embodied in the accompanying report, with other necessary information.

In closing this report I desire to commend especially Mr. Theo. G. Ellis, whose service in making this survey I was fortunate enough to secure. Combining practical knowledge with a truly scientific mind, he has united these qualities to an earnest zeal in the prosecution of the work assigned him. Being a resident of Hartford, he possessed great facilities for obtaining all the information he required, and his report is not only all and more than was required by his instructions, but is valuable simply from the information it contains respecting the river—information never before collected, and most useful for future reference.

In case a more extended survey of the river should be required, comprising a detailed survey of the river between Hartford and Middletown, a general survey for the purpose of delineating correctly the banks between Middletown and the mouth, and a detailed survey of the mouth, I would estimate the sum of $5,000 for that purpose.

I am, general, very respectfully, your obedient servant,

D. C. HOUSTON,
Brevet Colonel United States Army.

Brevet Major General A. A. HUMPHREYS,
Commanding Corps of Engineers U. S. A., Washington, D. C.

P. S.—The maps relating to this survey are sent to the department in a separate package by the same mail with this.

P 4.

COLONEL: A survey of the Connecticut river has been made in conformity with instructions received from you in August last, requiring "a

survey of such portions of the river as required improvement, below the city of Hartford, with a map and report," and stating that "the object of this survey is simply to inform Congress as to the condition of the river, so that it can act intelligently in making appropriations for its improvement. Although called a survey, it ought to be called an examination, for it is not intended to make an elaborate survey but only so far as the above mentioned object requires. I desire then a reconnoissance of the river, with special examination of those points where improvement is required."

You also furnished me with copies of an extract from the act of Congress authorizing the survey, which is appended, and marked A, and extracts from the War Department circular relating to what was required in my report, which is also appended, and marked B.

A tracing of the Coast Survey chart of Saybrook bar was also furnished me, with the remark that "an examination of Saybrook bar, with a view to deepening the channel over it will also be comprised in this survey. We have, however, a survey of this, which I inclose, so that all I ask of you is to ascertain what has been done there in former times, and its results."

Having the above objects in view, the survey was commenced under my direction, about the middle of August last, and field operations were carried on under two principal parties, with assistants at Hartford and Middletown, to observe the fluctuations of the river, until the last of October. One of the parties again took the field for a short time in November, but most of the time since has been employed in making up the notes and preparing plans.

Although we were especially favored with fine weather during the progress of the field operations, yet the season became so late before completing the surveys of those parts of the river requiring examination, that little or nothing could be done towards ascertaining by observation what changes have taken place in the bar at the mouth of the river.

It is believed, however, that every point in the river where obstructions now exist, or have existed within the past few years, have been examined with sufficient care to determine their nature, and what is the best means of overcoming them.

The other items of information required by the circular from the War Department have been derived from various sources, where they could be best obtained. The information relating to the commerce of the river has been principally derived from the evidence given before the committees of the State legislature with regard to bridging the river at Middletown and Lynn, and may be relied upon as accurate.

The information embodied in this report regarding the changes in the channel of the river, high and low water marks, and the building of piers, is given upon the authority of various persons who have resided a long time near the river, or navigated its waters. Their statements are corroborated by others, and it is believed that very little of what is stated will be found to vary materially from the real facts of the case.

METHOD OF SURVEYS.

The method employed in making surveys of those portions of the river where obstructions exist was generally as follows:

Base lines were located on each side of the river as nearly as possible in the direction of the bank, and with as few angles as could be obtained sufficiently near the river, and the ends and angles of these lines con-

the oars, generally three. The character of the bottom as well depth was observed at each sounding.

The velocities of the current at several places across the strea taken at the most important points, with a view to making a co of the distance run by the boat between the observations for th ent velocities of the current at the sides and middle of the strea as it was found most convenient, for the purpose of keeping mor and easily in line, to make the observations at such times as was setting up stream, and thereby reducing and at times neut the force of the current, or when the wind, blowing up stream, in producing the same effect by its action upon the boat, this co was found to be immaterial to the accuracy of the position of th ings. Before commencing the soundings at any point, a certain was established upon the bank, generally by driving several stak fully to the same level, and immediately before taking a line of ings across the river, the level of the surface of the water was det from one of these stakes, and entered upon the notes. By thi the soundings from the variable surface of the water were all ref one level at each point where a survey was made. It then becam sary to reduce the soundings to low-water mark at each point, other level of the river, the exact height of which above low-wat was known.

In order to do this, observers were stationed at Hartford and town, the only places on the river where low-water mark was who observed the height of water each 10 minutes during t This gave the fluctuations of the river at these points. The tid also observed for 24 hours at several intermediate points to de the form of the wave. The level assumed as mean low water which all the soundings of the survey are reduced, is the lowest water during the past season, which occurred during the progre survey. This was supposed also to run out at mean low water brook.

For the purpose of reducing the soundings, the tidal wave w

Middletown, and Saybrook. At some of the minor points, where there was no maximum or minimum height of water observed, the tidal wave was taken as moving up stream uniformly to obtain the time of high or low water at those places. The proper height for the nearest observation to high or low water was then computed from the general form of wave at the nearest point taken, as shown by the 24-hour diagrams prepared for the purpose.

The velocities of the current observed were taken with a float of thin pine, about four by six inches, sunk to the surface of the water by lead on the lower edge, and rigged somewhat like a ship's log. The line was run out by hand, without resistance, and the number of seconds observed between two knots of red flannel, 100 feet apart.

CHARACTER OF THE RIVER.

The Connecticut river rises in the extreme northern part of New Hampshire, almost upon the border of Canada, and flows southwardly between the States of New Hampshire and Vermont, crossing the States of Massachusetts and Connecticut, its whole course lying within the limits of the United States.

In the States of New Hampshire and Vermont its water bed is narrow and precipitous, and its tributaries are mostly small, partaking of the character of mountain torrents.

The principal tributaries in New Hampshire are the upper and lower Ammonoosuc and Ashuelot rivers; and in Vermont, the Passumpsic, White, and West rivers.

In Massachusetts, the Chicopee and Miller's rivers enter it from the east, and the Deerfield and Westfield rivers from the west.

The principal tributary in Connecticut is the Tunxis, or Farmington river. It rises on the easterly slope of the Green mountains in Massachusetts, and flows southerly to Farmington, where it makes an abrupt bend to the north and passes through the range called "Talcott mountains," when it again turns southerly and enters the Connecticut opposite the town of East Windsor. Below Hartford, the streams which enter the Connecticut are small, and, except in rain storms, furnish but little water.

From its source to the Massachusetts State line, the banks of the Connecticut are generally of a permanent character. Through the State of Massachusetts the river passes mostly through an alluvial formation, though in some places the bed is formed of hard and permanent materials. From the town of Northampton to Hartford, the river passes through alluvial meadows overflowed in high freshets. Through Massachusetts and Connecticut the banks are not generally wooded, but occasional patches of woods and many single trees stand upon them.

The river is navigable for schooners and steamboats to Hartford, and, by means of canals around the falls and rapids, it is navigable for small craft through the whole length of Connecticut and Massachusetts.

In accordance with the objects of the present survey, the river has been more particularly examined from Hartford to its mouth, embracing that part which is capable of being improved and rendered navigable for larger vessels than at present.

The first bridge across the river occurs at Hartford, where there are two—one, a toll-bridge at the foot of Morgan street, above the wharves, and the other the bridge of the Hartford, Providence, and Fishkill railroad, just above the city. These bridges are furnished with draws, though they are rarely, if ever, opened. As they are now, they

effectually make Hartford the head of navigation. The next bridge above, that of the Hartford and Springfield railroad at Warehouse point, was built without a draw, although the charter of the road requires that there should be one.

From Hartford to Rocky Hill, a distance of nine miles, the banks of the river are generally a clayey loam upon the outside of the curves or bends, and upon the opposite side, low sand beaches, deposited by the river in freshets. The banks upon the outside of the bends are about 12 or 15 feet high, and are washing away rapidly, generally caving off by being washed under; but in some cases the clay slides out from the bottom and rises up in the river, the top sinking down for perhaps 20 or 30 feet back to eight or 10 feet lower than before. The part that slides out into the river soon washes away, and the operation is repeated.

The bottom of the river is generally gravel or sand, being quite hard in the channel.

From Rocky Hill to the narrows below Middletown, the banks are generally more permanent and less subject to wash. At two or three places, however, they are wearing away by the action of the water. One of these is about two miles below Rocky Hill, where the banks are of sand, and another at Gildersleeve's island, about three miles above Middletown, where the bank is composed of sand and clay, and is washing away rapidly.

Through the "straits," for a distance of about a mile, the banks are high and rocky, and the channel deep and narrow. From this point to the mouth of the river the banks suffer but little abrasion from the action of the water, and are generally hilly, sloping downward to the river, and in many places rocky.

At the mouth of the river, as is usual in all streams that bring down sediment from an alluvial region, a bar has formed, composed of sand and mud, deposited mostly in time of freshets.

CHANGES IN THE BED OF THE RIVER.

That part of the river lying between Hartford and Rocky Hill has evidently been subject to many changes of its bed. At Hartford the river has moved to the west until it encountered the high, sloping ridge upon which Hartford is built, and the shore was protected by wharves. Below Hartford it has changed somewhat, as will be mentioned further on, but the greatest changes have occurred between the Hockanum river and Glastenbury. A sketch in a book published in 1838, called "Historical Collections of Connecticut," shows that at the time the country was first settled, the river ran from near the mouth of the Hockanum around a bend now forming Weathersfield cove, and then around another bend through what is now Keeney's cove. Crossing Pratt's ferry near its present bed, it then ran to the westward of the present channel and joined it lower down. This change is shown by the fact that part of the town of Glastenbury, which was formerly bounded by the river, now lies upon the west side of it. At present both of the bends in the locality above mentioned are extending and making the channel more serpentine, and at the same time moving down stream. In several places the change within 30 or 40 years has been more than the width of the river, so that land formerly owned by persons now living, lying upon one side of the river, has been passed over and now lies upon the opposite side.

Further down, opposite the city of Middletown, the channel has changed from the west to the east side of the island since the year 1807;

for in October of that year the legislature passed a resolution directing the Union Company to "desist from attempting to form a channel to the east of the island, opposite the north part of the city of Middletown," showing that a change from the west side was contemplated at that time.

Below Middletown there does not appear to have been any important change in the bed of the river. At the place called Selden's cove the river may have changed its bed a long time ago, but it now appears to be permanently fixed between the present banks.

FRESHETS.

The Connecticut river is subject to freshets of considerable height, which occur principally in the spring, when the river is swollen by the melting snow, although freshets have occurred in every month of the year except June, July, and September. The highest freshets generally occur in the spring. There was one remarkable exception, however, in August, 1856, when the water rose to a height of 23 feet 4 inches above low-water mark. This was caused by extraordinary and unusually heavy rains which occurred at that time.

A few of the most extraordinary which have been known are recorded upon a gauge board at the toll-house at the west end of the bridge, across the river at Hartford. The zero of this gauge board, which is marked in feet and inches, is placed at the level of the low water of 1801, which, previous to 1858, was the lowest water on record. In the last year mentioned, the water fell to about 1½ inch lower. The flood of 1854 is erroneously marked on this gauge at 30 feet, when it should have been 29 feet 10 inches, as recorded at the time upon the same scale as the other flood marks. This is the highest water ever known in the river. Previous to the high freshets of May, 1854, and April, 1862, that of 1801 was the highest known.

From careful levels, taken from the different flood marks at Hartford and Middletown, and from records kept by Mr. Chapman, near the Hartford bridge, the following table of the remarkable floods in the Connecticut has been prepared. The heights at Hartford are from the zero of the gauge board at the toll-house, which is the conventional low-water mark, and those at Middletown are from six inches above the zero of the gauge board at the Portland quarries, which it is believed is extreme low water at Middletown, as near as can be ascertained:

Table of floods.

	Hartford.		Middletown.	
	Ft.	*In.*	*Ft.*	*In.*
Flood of 1801	27	6	23	8½
Flood of 1841	26	4		
Flood of 1843	27	2	22	11
Flood of December, 1844	19	6		
Flood of February, 1845	19	0		
Flood of April, 1845	19	0		
Flood of March, 1846	18	9		
Flood of April, 1847	21	0		
Flood of January, 1848	15	6		
Flood of November, 1849	17	6		
Flood of May, 1850	20	9		
Flood of January, 1851	14	6		
Flood of April, 1852	23	1½	19	5
Flood of May, 1853	16	0		

Table of floods—Continued.

	Hartford.		Middletown.	
	Ft.	*In.*	*Ft.*	*In.*
Flood of November, 1853	20	6	17	2
Flood of May, 1854	29	10	25	8¼
Flood of January, 1855	15	0		
Flood of April, 1856	16	3		
Flood of August, 1856	23	4	18	1
Flood of February, 1857	19	6		
Flood of October, 1857	18	3		
Flood of March, 1858	12	3		
Flood of March, 1859	26	5	21	10
Flood of March 1860	16	0		
Flood of April, 1861	21	6		
Flood of April, 1862	28	8	23	9¼
Flood of November, 1862	15	6		
Flood of May, 1863	15	0		
Flood of April, 1864	17	3		
Flood of March, 1865	24	9	20	0
Flood of May, 1865	18	0		
Flood of February, 1866	20	6		
Flood of April, 1866	13	10		
Flood of February, 1867	17	2		
Flood of April, 1867	20	0		
Flood of August, 1867	16	2		

The average difference of the heights of the nine freshets above compared, at Hartford and Middletown, is 4 feet 3¼ inches.

The great height of freshets at Hartford and Middletown is due to the contraction of the water-way at the narrows just below Middletown. The river is here only 650 feet wide at the water line, with precipitous and rocky banks rising to a great height on either side, so that the width does not probably exceed 800 feet at the highest water level. Through this gorge all the water must pass which in freshets overflows the banks above, and spreads out in some places nearly two miles in width over the meadows through which the river runs.

The effect of this contraction of the water-way is seen in the small fall in the surface of the water in floods, between Hartford and Middletown, given above. Middletown is about one-third of the distance from Hartford to the mouth of the river, and the average fall of water in high freshets between those points is only one-sixth of the mean height of the freshets above low-water mark at Hartford. The distance from Hartford to Saybrook light is 49 miles.

SEDIMENT AND DEPOSITS.

In the spring freshets the upper waters and tributaries of the Connecticut bring down great quantities of silt, which is deposited along its course and at Saybrook bar. At high stages of the river the water is dammed back by the straights below Middletown, and spreads out over the meadows above. A large proportion of the earthy matter held in suspension is thus deposited in the comparatively slow current over the meadows and along the channel of the river. Bars are formed wherever there are eddies, which remain after the water has fallen, and prove serious obstacles to navigation. These bars are generally washed down as the river falls, by the current in the channel. There seems, however, to be

in some places a hard bottom of gravel or coarse sand, which lies very firmly bedded, and does not wash away with the force of the current at low water. This remains and forms permanent bars or shoals.

The fine particles held in suspension are carried forward by the current and deposited lower down, or carried out over the bar at the mouth of the river.

After the water has fallen so as to be confined between the banks, in the alluvial region between Northampton and Rocky Hill, these banks are washed and carried off, furnishing a great amount of material to be deposited below.

VELOCITY OF THE CURRENT.

The velocities of the current in the river are so much affected by the height of the water and the tides that the limited number of observations taken during the progress of the survey do not form sufficient data to determine with accuracy the volume of water or the effect that the current of the river has upon the bottom at the different stages of the water. They show, however, some facts which are worthy of note. At Hartford bar the greatest surface velocity observed was in the narrow part of the channel, near the island marked B on the map, and opposite the end of the pier C. At each of these places the velocity was 3.06 feet a second, or 2.09 miles an hour. In the wider parts of the stream the velocity was 2.45 feet a second, or 1.67 mile an hour.

These velocities were taken when the height of the river was five feet above low-water mark.

Along that part of the river shown on sheet No. 1 the maximum velocity was about 200 feet from the west bank.

By observations taken at the commencement of the survey, when a sudden rise occurred in the river, the surface velocity in the channel opposite Colt's dike was four feet a second, or 2.73 miles an hour; and opposite the foot of Kilbourn street, just below the East Hartford bridge, it was 4.17 feet a second, or 2.84 miles an hour. At this time the river was 14.3 feet above low-water mark. At Weathersfield the velocities of the current were taken when the river was quite low. The maximum velocity observed was 1.64 foot a second, or 1.12 mile an hour, when the river was 1.8 foot above low-water mark and at low tide. The least velocity observed was 0.83 foot a second, or 0.57 mile an hour, at high tide, when the height of the water was three feet.

At Pratt's ferry the maximum velocity observed was 2.22 feet a second, or 1.51 mile an hour, taken when the tide was about half low, running out, and the height of water about 2.5 feet above low-water mark.

At Log bar the maximum velocity observed was 1.61 foot a second, or 1.10 mile an hour, taken when the tide was about half low, running out, and the water at 2.3 feet above low-water mark.

Near Glastenbury piers the maximum velocity observed in the channel was 2.70 feet a second, or 1.84 mile an hour, when the tide was running out, about half low, and the water about three feet above low water mark.

Near Dividend bar the maximum velocity observed was 2.50 feet a second, or 1.70 mile an hour, taken about two hours before low-water, when the river was 3.5 feet above low-water mark.

The minimum velocity observed at this point was 0.33 foot a second, or 0.23 mile an hour. This was at high tide, with the river at 4.5 feet above low-water mark.

Below Dividend bar no observations of velocities were made.

The following table shows the depth of water and the surface velocity at the different points, and also, in the fourth column, the computed velocity at the bottom of the channel in feet a second:

	Height of water.	Surface velocity.		Bottom velocity, feet a second.
		Miles an hour.	Feet a second.	
Foot of Kilbourn street	14.3	2.84	4.17	2.50
Hartford bar	14.3	2.73	4.00	2.40
Hartford bar	5.0	1.67	2.45	1.47
Opposite pier C	5.0	2.09	3.06	1.84
Weathersfield	1.8	1.12	1.64	.98
Weathersfield	3.0	.57	.83	.50
Pratt's ferry	2.5	1.51	2.22	1.33
Log bar	2.3	1.10	1.61	.97
Glastenbury piers	3.0	1.84	2.70	1.62
Dividend bar	3.5	1.70	2.50	1.50
Dividend bar	4.5	.23	.33	.20

According to Du Breat, the greatest velocities of the current close to the bed, consistent with the stability of material, are as follows: Soft clay, 0.25 foot a second; fine sand, 0.50 foot a second; coarse sand, 0.70 foot a second; gravel, 1 foot a second; coarse gravel, 2.25 feet a second.

According to this it would appear that at Hartford bar and Pratt's ferry the current is sufficient to move the material of the bottom, unless it has become so hard and packed as to resist the action of the water; which from the notes taken of the soundings would seem to be extremely probable, as the lead would strike hard and firmly against the bottom at those places.

At Glastenbury piers and Dividend bar the channel now scours out to a sufficient depth.

TIDES, ETC.

During the progress of the survey it became necessary to make observations upon the tides and other fluctuations of the river, in order to reduce the soundings taken to a uniform level, or stage of water. Observations were taken at Hartford and Middletown with this view, as these were the only places where there is any standard low-water mark.

At Hartford the observations were taken near the bridge at the foot of Morgan street.

At the toll-house on the Hartford end of the bridge is the board upon which is recorded the height of the most extraordinary freshets in the river before mentioned. The zero of this board was taken for low-water mark, and is the point known as such when speaking of height of water in the river.

The water has, however, been known to fall below this zero, upon at least one occasion. At the northeast corner of Chapin's wharf, upon a large firm pile, the second from the end, are driven four spikes, put in at the lowest stages of water in different years. The lowest one was driven by Mr. E. B. Farnham, of Hartford, at the extreme low water of August, 1858, and is .11 of a foot lower than the zero of the gauge at the toll-house. This is the lowest water known. The next spike is .12 of a foot higher, corresponding to about the zero of the gauge board,

and is said to have been driven by a Mr. Hempstead, the former surveyor of the Union Company. The other two spikes are higher up. One was driven by Mr. P. B. Goodsell, surveyor of the Union Company, in 1833, and the other by some person unknown.

At Middletown the observations were taken near the ferry to Portland, and the point assumed as low-water mark, to furnish a base for the observations, was the zero of a gauge board upon the corner of one of the wharves at the Portland quarries. No definite information could be obtained regarding the extreme limit of low water at Middletown, and it is extremely doubtful if it ever reaches the zero of the scale above mentioned. At the lowest stage of water observed during the present survey, the height of the river appeared to be about the same above the two zero points at Hartford and Middletown. It is probable, however, from a comparison of the heights at different stages of the river, that when the water was down to zero of the Hartford scale, it would correspond to about six inches of the scale at Middletown.

The lowest state of water observed was on the 1st of October, when the water, at low tide, was 1.48 foot above the zero at Hartford, and 1.46 above the zero at Middletown.

This height was assumed as mean low water, and to it all the soundings between Hartford and Middletown are reduced.

Between Middletown and Saybrook bar, the soundings are reduced to the height of 1.46 foot above the zero at Middletown, and mean low water of the tide-water at Saybrook.

From the observations taken between the 20th of September and the 20th of October, the mean rise and fall of the tidal wave and the time of its passage up the river have been computed.

The rise and fall of the river from rains, and the effect of winds, cause so great a disturbance in the tides upon the river, that the heights and periods of the successive tides are extremely variable, even in the lowest stages of the water.

In high freshets the tides are not felt at all at Hartford and Middletown, but in the low stage of the water they are perceptible at Windsor locks, 12 miles above Hartford.

The mean rise and fall of the tides at Hartford, as determined by the observations taken, is .85 foot; the average height of the water at low tide being 2.49 feet, and at high tide 3.34.

The greatest tide observed was upon the 27th day of September, when the river at low water was 1.82 foot above low-water mark and the weather calm. On that day the tide was 1.24 foot.

The least rise was upon the 9th day of October, when the height of the river at low water was 3.57 feet, and the wind light from the southwest; on that day the tide rose .25 foot.

The highest water was on the 14th day of October, when the river stood at 4.60 feet above low-water mark.

The lowest water was on the 1st day of October, when the river stood at 1.48 foot above low-water mark.

At Middletown the mean rise and fall of the tides, as determined by the observations taken, is 1.93 foot; the average height of the water at low water being 2.13 feet, and at high tide 4.06 feet.

The greatest tide observed was upon the 2d day of October, when the height of the river above low-water mark or zero of the gauge was 1.77 foot, and the wind light from the southwest. On that day the tide rose 2.47 feet.

The lowest rise was upon the 9th day of October, when the height of the river at low water was 2.50 feet, and the wind light from the southwest. On that day *the tide rose* 1.13 foot.

than the bottom, or low water. We consequently find a less t
tween low water and the succeeding high water the further we
moved from the mouth of the river. At Saybrook the mean dur
the rise of the tides is 6*h*. 9*m*. The mean duration of the fall is

At Middletown, the mean duration of the rise is 4*h*. 55*m*. Th
duration of the fall is 7*h*. 30*m*.

At Hartford the mean duration of the rise is 4*h*. 15*m*. Th
duration of the fall is 8*h*. 10*m*.

The high tide on the top of the tidal wave passes from Sayl
Middletown in 3*h*. 25*m*., and from Middletown to Hartford in
making a difference of 5*h*. 30*m*. in the whole distance.

The low tide or bottom of the wave passes from Saybrook to
town in 4*h*. 39*m*., and from Middletown to Hartford in 2*h*. 45*m*.,
a difference of 7*h*. 24*m*. in the whole distance.

Thus we see that the high tide moves from Saybrook to Ha
1*h*. 54*m*. less than the low tide.

According to the determination of the United States Coast S
1838 and 1851, the corrected establishment or average time betv
moon's southing and the time of high water at Saybrook is 1
This would give the corrected establishment at Middletown 1
and at Hartford 15*h*. 47*m*.

WHAT HAS BEEN DONE ON THE RIVER.

What has already been done in the way of improvements u
river will be, in a great measure, described when speaking of the
tions in the channel, as the subject will be better understood wh
in connection with the description of the localities and natur
obstruction it was intended to obviate or overcome by the
employed.

A few remarks, however, upon the improvements made by th
Company, and their character, will assist in understanding the

The Union Company was chartered by "An act for incorpor
company to clear the channel of Connecticut river," passed in

Hartford and Middletown; to increase the depth of water to six feet, and of a suitable width to enable vessels to pass."

This charter was to remain in force for 60 years. The tolls were fixed for vessels of different draughts of water, according to the distance they went up the river, at from $6 to $38 for draughts of from six to ten feet. This charter was amended in unimportant particulars in 1801, 1803, 1807, 1810, 1812, and 1828.

The company commenced work in 1801, and built several rough-stone piers in the river between Hartford and Middletown. The first was a pier opposite Dutch Point, in Hartford, on the east side of the river.

Hartford Bar pier, or rather part of it, was built the same year. This bar had been then for some time the most difficult place to pass of any in the river.

Previous to the commencement of the Union Company's operation in the river, there were eight sand-bars between Hartford and Middletown, which were serious obstacles to navigation. On several of them the depth of water at average tides, according to different statements made by reliable persons under oath, in 1831, was only from five feet six inches to five feet ten inches. One statement was, that "at the ordinary state of the river at the height of the tides the depth of water in the bars varied from five feet eight inches to six feet."

There were also in the river a number of logs, from which two of the bars derived their names, which were a great impediment to vessels, and which the company removed.

They also removed logs at the mouth of Little river, in Hartford, and up to the year 1835 expended considerable sums in building piers, stoning the banks of the river in several places, and planting willows to protect the banks, and materially improved the navigation up to that year.

The amount expended by the company from the commencement of their operations to the year 1835, inclusive, in clearing the channel and improving the navigation of the river, was $44,271 11. After the year 1835 considerable was done by the company, of which I could find but litte information.

According to the report of the commissioners "appointed by law to examine the works erected and established by the Union Company in Connecticut river, between the towns of Hartford and Middletown, and to determine the depth of water on the several bars between those places," the least depth of water in the channel, from the top of high water at common tides, in the month of August, on the shoalest bar between Hartford and Middletown, was as shown in the following table.

The last column shows the height reduced to low water by deducting the height of an average tide at the points named:

Year.	Place.	Depth at high water.		Depth at low water.	
		Ft.	*In.*	*Ft.*	*In.*
1826..	Log Bar Junior	7	9	6	5
1827..	.....do	6	7	5	3
1828..	.....do	7	9	6	5
1829..	Log bar	6	8	5	5
1830..	Hartford Bar Junior, (clay banks)	7	5½	6	5½
1831..	Log Bar Junior	7	4	6	0
1832..	Hartford Bar Junior, (clay banks)	8	0	7	0
1833..	.....do	7	6	6	6
1834..	.....do	7	8	6	8
1834..	Hartford bar	7	8	6	10

Year.	Place.	Depth at high water.		Depth at low water.	
		Ft.	*In.*	*Ft.*	*In.*
1835..	Hartford bar	7	5	6	7
1836..	Hartford Bar Junior, (clay banks)	7	2	6	2
1837..	Log Bar Junior	7	3	5	11
1838..	do	7	8	6	4
1838..	Hartford Bar Junior, (clay banks)	7	8	6	8
1839..	do	7	11	6	11
1840..	do	7	11	6	11
1841..	do	7	5	6	5
1842..	do	7	5	6	5
1843..	do	7	0	6	0
1844..	Log Bar Junior	7	6	6	2
1845..	Hartford Bar Junior, (clay banks)	7	0	6	2
1845..	Log Bar Junior	7	0	5	8
1845..	Glastenbury bar	7	0	5	8
1846..	Hartford Bar Junior, (clay banks)	8	9	7	9
1847..	Log Bar Junior	8	0	6	8
1848..	Hartford Bar Junior, (clay banks)	8	0	7	0
1849..	Log Bar Junior	8	4	7	0
1850..	Hartford Bar Junior, (clay banks)	8	0	7	0
1851..	do	8	0	7	0
1852..	do	8	4	7	4
1853..	do	8	6	7	6
1853..	Dividend bar	8	6	7	0

The works of the Union Company were but temporary expedients, and most of the piers built by them have become obstacles themselves instead of aids to navigation.

During the past few years the steamboat company have been engaged in improving the channel by dredging. The points where they have worked will be given further on.

They have already expended about $34,000 in this manner, and the city of Hartford has contributed about $12,000 for the same purpose.

About 20 years ago the United States government dredged out a channel over Saybrook bar, but no reliable information can be obtained here of when the work was done, or how extensive it was intended to be.

It is the opinion of Mr. Smith, the president of the steamboat company, that the channel which was then dredged out, soon filled up again; but for how long a time the benefit of the dredging was apparent nobody seems to know.

Perhaps the channel opened was not in the position of the present course of vessels over the bar; the Coast Survey chart of the mouth of the river, made in 1849 and 1851, herewith appended, showing deeper water on another part of the bar than in the channel at present used.

The work done may, however, have been subsequent to the above survey.

Until within about 14 years, boats ran through the eastern channel shown on the Coast Survey chart, but about 1853 changed to the one now used.

About five or six years ago this channel was scraped out with a plowing apparatus drawn by tugs, with considerable benefit.

OBSTRUCTIONS AND PIERS.

The principal places where obstructions have existed or now exist in the river are as follows:

Just below the city of Hartford a bar has formed across the river,

shown on sheet No. 1, which during the past season has been the most troublesome place on the river. At this place, according to the best accounts, the river has moved to the west some 300 or 400 feet within the past 40 years. At the wharves in Hartford, and at the old pier marked C on the map, the bed of the river has remained nearly stationary. This change in the bed of the river was caused partially by a pier built 66 years ago on the east side of the river, opposite Hartford, by the Union Company, which deflected the current to the opposite side of the river and washed away about 200 feet of the bank, where Colt's depot now stands. Below this the bank has been gradually washing until at present it is becoming dangerous near Colt's embankment. The bank on this side of the river varies from four or five to 12 or 15 feet high, and is a stiff, yellow clay, with some compact and hard streaks, which resist to a certain degree the action of the water. The top of the bank is covered with a small growth of willows interspersed with young elms and poplars.

Before Colt's dike was built, there were small stone piers to protect this bank.

The bank of the river upon the east side has become filled out with sand deposited in freshets. The bank at present is about five feet high, where 40 years ago there was said to be about five feet of water, showing an average deposit of three inches a year. During the high water of last August there was a deposit of one-third of an inch upon the surface of the meadow.

The bank is fringed with small trees, some of which may be 20 years old.

The bottom of the river on the east side is hard sand, in some places formed into small ridges running at right angles to the bank and sloping gradually to the channel, where the material changes to coarse sand and gravel. On the west side of the channel, the bottom is hard clay, though in some places, and especially along the water's edge, the sand deposited by freshets still remains.

Near the west bank is a small island, shown at B on the maps, which a few years ago was a projection into the river called the natural wharf. The water has washed behind it and is leaving it in the channel, where it will soon become a very serious impediment if not taken care of. The channel will also probably work around so as to pass between this island and the west bank, which would seriously endanger Colt's embankment.

The shoalest water in the channel is opposite this island, where the depth below extreme low water is 5.8 feet.

The old pier marked C on the map was built by the Union Company; about one-third of it in the year 1801, soon after the formation of the company, and the other two-thirds about 30 years ago. This pier was built in deep water, and what effect it was intended to produce upon the channel I have not been able to ascertain. Just below the Union Ferry dock is a small pier marked D on the map, which has been built to protect the bank and does not at present offer any obstruction to navigation. (See sheet No. 2.)

Below this is a stone heap, marked E on the map, lying about 75 feet from the shore, supposed to have been placed on the bank by the Union Company. The bottom around this stone heap is clay. This is somewhat of an obstruction to sailing vessels, but not to steamboats or tows.

The pier marked F on the map was built about 15 years ago to protect the bank, which is a stiff clay. It has been worn away inside of the pier a distance of about 50 feet. This pier is little or no obstruction to navigation, as the channel is wide at this point.

The left bank is a steep bank of clay, rising directly from the line to a height of 10 or 12 feet. On this side of the river is marked G on the map, which was built by Mr. Horace Williams, t ent owner of the land, to protect it. It is merely an irregular broken stone and mud. At present it does not offer any serious tion to navigation, but in the course of a few years it will prob left in the channel by the action of the water upon the banks. somewhat protects the banks from washing.

This bank was covered with broken stone 32 years ago, sinc it has washed away about 150 feet.

Just outside of the pier G is a small heap of stone, marked H map, which is a considerable obstacle, as it lies directly in the No account was obtained of how it came there.

The channel is shallow at this place, and has been in years serious impediment to navigation. The depth of water at prese extreme low water is seven feet. Below these points a sand shoal h out from the right bank, and is at present rapidly increasing in

The piers I and J, shown on the map, were originally built o the left bank to protect it and to improve the channel. They w structed by the Union Company many years ago. Until within ab years these piers forced the channel over to the right bank river. The shoal then began to make out from the right ba crowded the channel more against the piers. It worked around I so that during the years 1863 and 1864 vessels passed to the the pier I and crossed the river between the two piers. In 1 steamboat company dredged out the channel to the east of pier which time it has been extending gradually into the left bank river.

The old meadow road, shown on sheet No. 3, ran 30 ye along where the bed of the river now is, extending out about o of the way across, showing the extensive changes that have take in the bed of the river at this point.

The pier marked K on the map is a mass of broken stone a

The channel, in crossing from the right bank to the Nambric wharf, passes over a bar on which there is very little water, and the channel is narrow and crooked.

At the upper part of the survey, on sheet No. 4, the bank is a clay loam, rising about 12 or 15 feet to the level of the meadow, and is washing away rapidly, at the rate of perhaps about 15 feet a year. Below the sunken tree shown on the map it is covered with timber. Further down a sand beach is gradually forming out from the shore.

On the left bank of the river, at Keeney's Point, the bank is low and sandy, and is making out into the present bed of the river.

The bottom of the river, from the right bank out nearly to the channel, is soft and sticky, seeming to be formed of the soft loam of the bank. In the channel it is hard sand and gravel, and on the north side it is sand mixed with the alluvial deposits of the river.

The sunken tree shown on the plan lies in the position drawn, and materially assists in forming the deposit on the bar. The least depth of water in the channel upon this bar is 6.6 feet below extreme low water.

About a mile below Pratt's ferry is Log Bar pier, marked M on the map and shown on sheet No. 5, and about 900 feet further down is a small pier marked N. These piers were built out from the south bank by the Union Company, about the year 1840, to protect the bank and improve the channel. Log Bar pier now lies partly imbedded in the north bank, the river having moved about 400 feet to the south since the pier was built. Ten years ago the channel ran to the north of both these piers; about that time it changed to the south of the pier M, and ran between the piers until the spring of 1866, when it changed to the south side of pier N. Since that time part of each of these two piers have been removed to improve the channel by the steamboat company.

The bank on the south side is high and consists of a clayey loam. The bottom of the river in the channel is coarse sand and gravel, running into sand upon the north bank. The north bank is a low beach of sand mixed with earth deposited by the river.

Half a mile below Log bar is a sunken tree near the right bank, which is a considerable obstruction, as the bank is steep and washing away very rapidly, which will soon leave it in the channel. The left bank is pure sand, with no vegetation for several hundred feet back from the river. The point at the bend of the bank is shallow, and the shoal makes out well into the stream.

The wall P seems to be a simple layer of stone placed upon the water's edge to protect the bank. The cutting away of the shore has, however, made an opening behind it and left it just at the edge of deep water, where it will tumble in after a short time.

The bottom at this place, in fact, from O to P, is "sticky" near the right bank, gravelly in the channel, and sandy on the opposite shore.

The eastern bank is low and covered with quite a heavy growth of willows. Below this last point is an old pier and heap of stones, marked Q on the map and shown on sheet No. 6, which is called Log Bar Junior. This pier was built from the left bank of the river by the Union Company to improve the channel, and it now lies imbedded in the opposite bank, where it is mostly out of water at low-water mark. The channel is now close to the left bank and is narrow, but of sufficient depth.

At the point R upon the map is an old sunken wharf, which is a serious obstruction to navigation. It was originally built on the eastern shore, but the wearing away of the bank has left it about 250 feet out, and upon the opposite side of the channel; within a few years it has been partially dredged out. What is left consists of loose stones with

part of the east end of the pier. The steamboat company h
dredged out about one-third of the west end of the pier T w
year or two, to improve the channel, yet it now remains tortu
difficult for the large steamboats and sailing vessels.

The bank opposite the end of pier S is wearing away rapid
below the pier T it is filling out. The left bank is of the ch
already described, being a clayey loam. The bottom of the ch
gravel, running into sand towards the right bank, which is a b
pure sand.

Some distance further down the river are the piers marked U
on the map and shown on the sheet No. 7, about a quarter of
apart, at a place known as Dividend bar. The channel line chang
the west side, opposite to the pier U, to the east side, oppo
pier V.

The first mentioned pier lies out a short distance in the riv
the east bank, and has an extensive shoal formed around it. T
V lies close to the west bank, and is half out of the water at lo
mark. It has deep water off the end of it.

The banks on which these piers are built are low, and the o
banks steep and covered with woods. The river bed is sand, with
in the channel.

About three miles above Middletown is Pistol Point bar, wh
at the upper end of Gildersleeve's island. This is marked W
map and is shown on sheet No. 8. Here there were two piers l
the Union Company, one long one from the right bank, and the o
the opposite side of the river, just above a brook which here ent
the Connecticut.

This latter pier has been nearly all dredged out in consequ
changes in the channel requiring it, and the stone has been de
upon the other side of the river, forming the hook to the north
the opposite pier shown on the map. The shoal extending
from Gildersleeve's island, and the bar to the northward extend
from the left bank, form a serious obstacle to the navigation

left is mostly clay, and is rapidly washing away from the small piers before mentioned to opposite the lower part of the island, near Gildersleeve's wharf. Below that point the bank is rock.

The rapid current running through the narrow channel east of the island will soon widen it by cutting in back of the small stone wharf and pier shown on the map opposite the middle of the island, when those will become serious obstacles in the channel, and will require removal.

The bank just above the wharf is loamy, and has been cut into already, so that it stands nearly vertical in the small bend seen on sheet No. 8, and forms an eddy that will speedily cut its way behind the wharf. At present the water is 22 feet deep within one foot of the bank at the water line.

The bottom of the river at this place is generally a hard sand. The least depth of water upon the bar in the channel is 5.9 feet.

Vessels have now some difficulty in working through the narrow channel east of the island, but the river will constantly widen at this place till the current becomes less rapid.

About a mile and a half below Middletown is Mouse island, marked X on the map and shown on sheet No. 7, which lies about 500 feet from the right bank, and between which and the bank lies the channel.

This island is above water at low stages of the river, and is formed of a hard material, containing loose stones of six inches and under in diameter. The channel is narrow but deep, and runs close to the right bank, which appears to be permanent.

The bottom is gravel in the channel, stony around the island, and sandy towards the opposite shore. The next point where there has been any serious obstruction is at Sears's shoal, marked Y on the map, which lies about a mile and a half above Higganum. At this place the river widens out and forms a shoal in the middle, extending about three-quarters of a mile up and down the river, ending in a fish pier marked Y. The channel here has been improving during the past few years, and at present this shoal does not offer a serious impediment to navigation. The bottom of the river here is a hard sand.

Half a mile above Deep river is Chester Rock, marked Z on the map and shown on sheet No. 9, which lies directly in the channel, so that vessels pass on either side of it within 15 feet.

This rock has a smooth top surface, which lies 5.8 feet below mean low water, and is of the rise and shape shown.

The bottom of the river is hard sand. The right bank is a low, marshy meadow, and the left bank is rocky.

The stone heap shown at Z on the map is probably a fish pier, and offers no obstruction to navigation.

The bar at the mouth of the river is, perhaps, the most serious obstacle to the navigation of the Connecticut that is to be disposed of. A survey of this was made by the United States Coast Survey parties in 1849 and 1851, and a copy of the chart prepared by them is appended. Important changes have, however, taken place since that time, altering the channel.

The channel at present used by the steamboats and other vessels navigating the river, is shown by the dotted line upon the chart of the bar annexed. This channel, according to the evidence before the committee of the legislature in 1866, was 100 feet wide.

An attempt was made to take soundings upon the bar during the month of October, but the weather proved too rough for the purpose. The position of the spar-buoy marking the present channel was, however, fixed, and is *shown on the chart.*

An approximate estimate of the depth of water was derived from crossing the bar on two occasions in the steamboat State of New York at nearly low tide, when she just passed over, touching the bottom. From the draught of the boat, as given by the captain, and the time which was then noted, a computation of the depth of water at mean low water was made. One of the observations gave a depth of 7.3 feet and the other 6.9 feet.

At Hayden's Point, half a mile below Essex, there are some rocks and a pier marked A on the map, and shown on sheet No. 10, but the channel is deep and good outside of them, and they do not materially interfere with navigation.

CHARACTER OF IMPROVEMENTS.

In considering the question of improving the navigation of the Connecticut several important questions arise as to what depth it is desirable to deepen the channel, and to what extent it is advisable to make an outlay for improvements which may be rendered useless by changes in the bed, which are always likely to occur in a river of the character of the Connecticut. It is also a question whether it should be endeavored to make the channel narrow and deep for steamers and tows, or, having a moderate depth, be wide enough for the passage of sailing vessels.

If it were of sufficient importance to give the channel of the river a depth of 12 or 15 feet at low water, and to render the channel permanent, this could be done by constructing parallel dikes at a proper distance apart, as has been done on the Clyde, the Dee, the Seine, and many other rivers, making them of sufficient height to carry all the water that ordinarily flows in the stream between them, but so that they would be overflowed by the high freshets, giving the river its full waterway. This would be done, but would involve an enormous outlay both for the dikes and for the extensive works that would become necessary at the bar to secure the proper depth of water at the mouth of the river. The trade of the Connecticut would not warrant the undertaking of any such improvement at the present time, although it is by no means improbable that such a project may at some future time be deemed advisable.

On many rivers, instead of constructing longitudinal banks as above, a series of transverse spurs are carried out from the banks for the purpose of deepening the channel, an attempt at which was made by the Union Company in the Connecticut. They act by confining the channel to narrow dimensions and form pools of still water below them where eddies form and silt is deposited. Their useful effect is, however, very small when compared with their cost, unless they are placed quite near together; the currents produced corrode the banks in a serious manner. If sufficiently close together, their length will equal and be quite as expensive as longitudinal dikes.

In all works intended to improve the navigability of a river, extreme care is required in attempting to alter its natural condition, whether of width or depth, because the result of any interference with them is always very uncertain. It is preferable in all cases to maintain the river within the limits nature has given it, rather than attempt to introduce great modifications, even though they should seem highly desirable.

For the present requirements of the river it appears to me that a much more moderate depth than could be obtained by dikes should be aimed at, and such improvements made in those parts of the river

which now offer the greatest obstacle to navigation, that they shall be made as practicable as those parts of the river that are now sufficient to pass the vessels at present navigating the river.

If it were attempted to give to the channel of those parts of the river which have heretofore given trouble a depth greater than is attainable at other points, those other points would become the bars and would likewise have to be deepened.

Under the instructions received, the present surveys have extended only to those parts of the river at which obstructions have heretofore existed, and have not been of sufficient magnitude nor embraced a sufficient portion of the river to determine the data necessary for extensive permanent works for the improvement of the channel. It was not contemplated to improve it to any greater extent than what is necessary to permit the vessels at present used upon the river to pass at all stages of the water.

This it is believed will be accomplished by giving the channel a depth of eight feet below low water mark, or nine and one-half feet below the level assumed as mean low water upon the accompanying maps, which is about one and a half foot above the lowest water ever known at Hartford, and which is perhaps about the average lowest summer level. The river has reached low-water mark at Hartford upon only two occasions that are known of since 1801, and does not perhaps once in 10 years get within six inches of it, and when it does it is only for a short time, in a favorable wind, and an extremely low tide.

It is proposed to make the channel in those places where dredging is resorted to 200 feet wide. This is believed to be a sufficient width. There are many places where it is narrower than this, but there the sides are generally well defined and the narrow places short and soon widening out to a much greater width than that above stated. This depth and width it is proposed to obtain by dredging out the channel upon the bars, and removing such piers and other obstructions as interfere with the navigation of the present channel, or throw the current out of its proper course.

Where the dredging is done in the proper direction of the current, the natural flow of the water will, in all probability, keep it clear until the banks become so changed as to alter the general course of the stream.

The bars are now of hard and packed material, which resists the action of the current, and if once dredged out would not probably again fill up so long as the river remains in the same bed. The silt deposited in the channel by freshets would probably again wash out as the water fell and leave the channel clear.

Upon the bar at the mouth of the river nothing can be done but to dredge out a channel to the required depth. According to the draught of water given of the State of New York, the depth in the channel on the bar is now about seven feet at mean low water. This would require that the bar should be dredged out one and a half feet deeper to conform to the additional depth given to the river, or eight feet below extreme low water.

As there has been no resurvey of the bar, no exact estimate of the quantity of material to be removed can be made.

Any means taken to increase the depth of water upon the bar will at best be but temporary. Dredging will improve the channel for a limited time, perhaps some years, but the history of such ports as Rye, Dunkirk, Aigues-Mortes, and others, shows that the permanent improvement of channels over bars is almost impossible.

survey, on sheet No. 1, were extended southward to the proposed l
it would be an additional means of preserving the depth of the cha
but it is believed that preventing the water from working to the
ward of the island marked B, and the slight deflection to the eas
given to the current by the piling, will preserve the channel of suff
depth.

The line of the proposed dredging is marked by black dotted lir
the sheet No. 1, and the line of the proposed piling by a broke
extending from the shore to the island B.

The material dredged out can be put into Weathersfield cov
Keeney's cove, about two miles below. At the pier C, below the l
does not appear necessary that anything should be done. The pie
helps the channel by deepening the water towards the eastern banl
should not be removed.

The small pier marked D is at present doing no harm, and w
require removal.

The stone heap marked E is not now in the channel, but wil
become so by the wear upon the banks, and requires to be remove

The pier F now lies just upon the edge of the channel, and will
ually have to be removed, but at present it lies just above a wharf
it serves to protect, and which would be an objection to its remova
such time as the river works its way behind it. For the presen
proposed to let it remain,

The pier G is at present doing good service in protecting the ba
the river, as was originally intended when it was constructed.
outside of it, however, is a small stone heap H, which now lies just
the west side of the channel, and between which and G a bar has f
which will require dredging out. The area to be dredged is inc
between the dotted lines.

The stone heap H will also require to be removed, which will p
the bar reforming.

The piers I and J are at present great obstacles to the navigat
the river by sailing vessels, and will require to be removed.
removal will promote, in a measure, the great wash of the bank now

nel in the direction of the natural current, 200 feet wide and nine and one-half feet below the lowest water of the present year, or eight feet below extreme low water. This will deepen the water upon the bar 1.5 foot.

The dredging will be about 1,400 feet in length and nearly in the present deepest water. The area is shown between the dotted lines on the sheet No. 4.

The material dredged out can be put on the right bank of the river, about two and a half miles below.

At Log bar and the old pier below, marked M and N on the map, nothing will require to be done, as the channel opposite these points is good and the piers will probably never do any harm.

At O the sunken tree which lies in the channel must be removed. The old wall at P is at present out of the channel, but will probably eventually be brought nearer the middle by the wash of the river, and it has consequently been considered better to remove it.

The pier at Log Bar Junior is now quite out of the way of the channel, and does not require attention, but there is a small stone heap near it which requires to be removed.

The old sunken wharf at R now lies directly in the channel, on the west side, with only about three and a quarter feet of water upon it at extreme low water. This will require to be taken out.

At the Glastenbury piers, marked S and T, although the channel is now of sufficient depth, it is extremely crooked and very difficult even for steamboats, except by daylight. It is thought best at this point to remove parts of each of the two piers and dredge out the channel, to make it more direct and prevent the great wash upon the bank that now exists opposite the end of the pier S.

By removing part of the pier S it is believed that the channel above will be made wider than at present, by removing the sand shoals that now extend out above the pier.

The material moved can be put on the other side of the river, below the pier Q. There is also a good place about a mile and a half down the river, near the east bank.

The piers marked U and V, at Dividend bar, are at present probably more benefit than damage to the channel, and should not be removed.

At Pistol Point bar, marked W, it is thought best to dredge out a channel, in the natural direction of the current, 200 feet wide to a depth of nine feet below the lowest water during the past season, or about eight feet below extreme low water. This will increase the depth of water in the channel 2.1 feet.

Most of the material removed can be put below the pier on the right bank of the river, opposite the island; or, if this should prove insufficient, part can be deposited on the left bank of the river, below Mouse island, about five miles distant.

The dotted black lines show the channel to be dredged out. It is also deemed best to remove part of the stone remaining of the small pier on the east side, just above the island.

At Mouse island, marked X on the map, it is not deemed advisable to do anything to the channel. It is sufficiently deep, although quite narrow.

At Sears's shoal, marked Y, the channel does not seem to be so shallow as to need improvement. The fish pier likewise is doing no harm.

Chester Rock, marked Z, will require to be taken out to a depth of three feet below the present highest point, as it lies directly in the channel. The fish pier near it can be allowed to remain without injury to the channel.

The rock and pier at Hayden's Point, marked A, can be left in their present position without injury to the channel, or impeding navigation.

At two or three places on the river, not mentioned above, there are trees in the channel that should be removed.

EXPENSE OF IMPROVEMENT.

The following is an estimate of the probable expense of improving the channel by removing obstacles and dredging, as above proposed:

At Saybrook bar no reliable estimate can be made from the survey of 1849 and 1851, on account of changes in the bar, but an approximation to the probable expense of a channel 200 feet wide and eight and a half feet deep, at mean low water, has been made and added to the estimate for the work upon the river.

ESTIMATE.

Hartford bar:		
Dredging 37,000 cubic yards, at 50 cents		$18,500 00
700 piles 14-inch butt, 18 feet long, at $2 75	$1,925 00	
Driving and flattening edges, at $2	1,400 00	
1,400 feet, 4 by 8 caps, 4 M, at $50	200 00	
235 bolts at 80 cents	188 00	
Work on capping, &c	150 00	
		3,863 00
Removing stone heap E:		
Loose rock, 107 cubic yards, at $1		107 00
Bar at Clay Banks:		
Dredging 3,750 cubic yards, at 50 cents		1,875 00
Removing stone heap H:		
Loose rock, 200 cubic yards, at $1		200 00
Removing pier I:		
Loose rock, 1,650 cubic yards, at $1		1,650 00
Removing pier J:		
Loose rock, 1,120 cubic yards, at $1		1,120 00
Gully below Weathersfield:		
Piling, 100 feet, at $5 50		550 00
Pratt's Ferry bar:		
Dredging 16,040 cubic yards, at 50 cents		8,020 00
Removing old wall P:		
Loose rock, 60 cubic yards, at $1		60 00
Removing stone heap at Log Bar Junior:		
Loose rock, 75 cubic yards, at $1		75 00
Removing sunken wharf R:		
Dredging 300 cubic yards, at 50 cents	150 00	
Loose rock, 100 cubic yards, at $1	100 00	
		250 00
Work at pier S:		
Dredging 9,070 cubic yards, at 50 cents	4,535 00	
Loose rock, 520 cubic yards, at $1	520 00	
		5,055 00

Work at pier T:		
Dredging 9,460 cubic yards, at 50 cents	$4,730 00	
Loose rock, 440 cubic yards, $1	440 00	
		$5,170 00
Pistol Point bar:		
Dredging 15,180 cubic yards, at 50 cents	7,590 00	
Loose rock, 65 cubic yards, at $1	65 00	
		7,655 00
Chester rock:		
Solid rock, 202 cubic yards, at $5		1,010 00
Removing sunken trees		150 00
Total for river		55,310 00
Saybrook bar:		
Dredging 15,000 cubic yards, at 60 cents		9,000 00
Total, including bar		64,310 00

The foregoing estimate is based upon what may be considered the present needs of the river in the way of improvements to render its navigation more easy and safe. From the character of the river, however, as has already been explained, it will require an additional expenditure each year to keep the channel in as good condition as the before-mentioned improvements would render it when completed. From the knowledge of the river acquired by personal inspection during the survey, it is my opinion that an annual outlay of $5,000 or $6,000 would keep the channel in good condition for vessels drawing nine feet of water to navigate the river at the usual low summer level.

This seems a small sum in comparison with the great amount received for freight and passengers transported on the river, and would be but a small percentage of the amount of freight. It would seem that the benefits to be derived from the proposed improvements would warrant a much greater outlay.

THE BUSINESS UPON THE RIVER.

The information regarding the business of the river and the amount of tonnage of vessels owned and used upon it, has been derived mainly from the evidence taken before the legislative committees in the springs of 1866 and 1867 upon the question of bridging the river below Hartford. The facts stated are compiled from the statements of various persons, but mostly from those of Elisha T. Smith, esq., the president of the steamboat company.

The river remains open for navigation an average of nine and a quarter months in each year. It closes about the 8th of December and opens about the 1st of March. For sailing vessels, the time is about eight and a half months.

There was owned in this district in 1865 shipping to the amount of 17,040 tons, valued at $1,800,000.

At Hartford about 40 men were in the same year employed in shipbuilding, and at Goodspeed landing, in East Haddam, vessels to the amount of 2,000 tons were built, valued at $250,000.

In 1866 the amounts of freight upon the river were nearly as follows:

	Tons.
Amount of freight both ways on steamboats to and from Hartford	74,200
Freight to Hartford by propellers and sailing vessels	201,600
Down freight by the same	16,000
Total Hartford freight	292,200
Freight between Hartford and Middletown	24,000
Freight from Portland	220,000
Freight at towns below Middletown	79,512
Total	615,712

In 1865 the amount was 569,000 tons. The total receipts for freight in 1865 were about $1,100,000. In 1866 it was said to be $1,350,000.

There are upon the river three large steamboats of from 1,500 to 2,000 tons, making daily trips to New York, and two smaller ones, one making daily trips to New London and Sag Harbor, and the other making two trips a day on the river between Hartford and Essex. There is also a line of propellers running to Albany, and one to Philadelphia.

In 1866 the number of passengers to and from New York by steamboat was	26,211
Way passengers on the river	27,008
By Sag Harbor steamboats	10,000
Total number of passengers	63,219

The total amount received from passengers by the steamboat company was	$125,550
By Sag Harbor, about	8,000
Total amount received	133,550

The number of trips to and from Hartford by the steamboat company's boats was	1,117
By Sag Harbor boats	208
By sailing vessels and propellers	1,836
Total number of trips	3,161

This is all I can learn with regard to the present state of the trade upon the river. There is doubtless much omitted that did not come under the observation of the persons whose evidence was taken, yet the amount named may be considered a good approximation to the actual business of the river.

Were the channel deepened so as to admit vessels of greater tonnage, the business of the river would undoubtedly be largely increased.

THE AMOUNT OF REVENUE IN THIS COLLECTION DISTRICT.

All of the improvements proposed lie within the collection district of Middletown, which embraces Windsor and all the towns below on the

Connecticut river except Lynn, also including Westbrook and Clinton, on Long Island sound, west of the mouth of the river.

With regard to the amount of revenue collected and the opinion of the collector, I cannot do better than to give his reply to my letter of inquiry in full:

CUSTOM-HOUSE, MIDDLETOWN, CONNECTICUT,
Collector's Office, October 14, 1867.

SIR: In reply to the inquiries made in your letter of the 11th instant, I will state that the amount of revenue collected at this office for the fiscal year ending June 30, 1867, was $17,967 01.

The average amount collected during the five preceding years was $11,389 87, showing an increase in the last over the five preceding years of $6,577 14, or about 36½ per cent.

In my opinion, the business on Connecticut river would be increased if the obstructions in the channel were removed, more especially on the portion above Middletown.

If the channel at Saybrook bar was improved so as to allow vessels of a larger draught of water to enter the river, I have no doubt the foreign trade on the river would greatly increase thereby enhancing the revenue of this collection district.

I am, very respectfully, your obedient servant,

O. UTLEY, *Collector.*

General T. G. ELLIS,
Engineer in Charge Connecticut River Survey.

List of maps and charts.

The following is a list of maps and charts accompanying this report:

A. A general map of the river from Hartford to the sound, showing the points referred to in this report.

B. A chart of the river at Hartford bar, showing the points B and C, (sheet No. 1.)

C. A chart showing the points marked D, E, F and K, (sheet No. 2.)

D. A chart of the river at the clay banks, showing the points marked G, H, I and J, (sheet No. 3.)

E. A chart of the river at Pratt's ferry, showing the point marked L, (sheet No. 4.)

F. A chart showing the points marked M, N, O and P, (sheet No. 5.)

G. A chart showing the points marked Q, R, S and T, (sheet No. 6.)

H. A chart showing the points marked U, V and X, (sheet No. 7.)

I. A chart of the river at Pistol Point bar and Gildersleeve's island, (sheet No. 8.)

J. A chart showing the points marked Y and Z, (sheet No. 9.)

K. A chart showing the point marked A, (sheet No. 10.)

L. A copy of the chart of Saybrook bar.

In concluding, I take great pleasure in expressing my obligations to the many persons from whom I have obtained information regarding the river, particularly to Elisha T. Smith, esq., the president of the steamboat company, and the captains of the river boats, from whom I have received much valuable information, and who have furnished me with every facility in their power during the progress of the survey. I am also much indebted to Wm. W. Eaton, esq., for the use of his notes of the evidence taken before the legislative committees herein referred to.

Very respectfully, yours,

THEO. G. ELLIS,
Civil Engineer.

Colonel D. C. HOUSTON,
United States Engineers.

P 5.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 22, 1868.

COLONEL: Your attention is directed to the report of Brevet Major General Warren's survey of the upper Mississippi river, (January, 1867,) a copy of which was some time since forwarded to you, for a description of Long's scraper in connection with wing-dams, or without them, for increasing the depth of water over the bars of rivers.

The removal of the bars in the Connecticut river seems to offer a good opportunity for the use of this contrivance, which has been applied with success by General Warren during the past season.

Should the velocity of the surface currents over the bar be (as reported by Captain W. H. Swift, topographical engineers) three feet per second, and the bottom fine, soft material, it might be removed by stirring up with a screw dredge, or a Long's scraper, and it might be advantageous to try these expedients before resorting to dredging by buckets.

You will please, therefore, examine into this subject and give your views thereon.

Your estimates for improving the river may be sufficient, but for the improvement of the mouth they are deemed inadequate.

The inclosed extracts from the annual reports of Captain Swift, the officer in charge of the former improvement, show the progress of the work, the difficulties he met with, and the reason for the increase of cost of dredging upon the Saybrook bar. They show also, conclusively, that no permanent cut can be made, but that the channel may be kept open, when once made by a small amount of yearly dredging, or what would be better, if feasible, by the use of scrapers or stirrers.

It would not be advisable to present your report of January 11th to Congress until the results of your further investigations are received.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General Engineers, Commanding.

Major and Brevet Colonel D. C. HOUSTON,
Corps of Engineers, Newport, R. I.

P 6.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, R. I., January 27, 1868.

GENERAL: I have the honor to acknowledge the receipt of your letter of the 22d instant, calling my attention to the report of Brevet Major General Warren of the survey of the upper Mississippi, (January, 1867,) and inclosing extracts from the annual reports of Captain W. H. Swift, topographical engineers United States army, on the former improvement of the mouth of the Connecticut river.

I have attentively read the report of General Warren describing the scraper devised by Colonel Long, and cannot doubt, from the statements therein contained and from his successful use of scrapers in the upper Mississippi during the past year, that it would be by all means advisable to try the use of them in deepening the water on the bars of the

Connecticut river, especially those above Middletown, before attempting to accomplish that object by the more expensive operation of excavation. Owing to the shifting character of the bed of the Connecticut, and the (almost) certainty that any artificial channel will require periodical efforts to maintain it, it is not so important that the material removed from the bars should be deposited where it will remain as is the case in other localities, where there is every reason to believe that a permanent channel will be maintained by action of the tides.

For this reason economy urges the use of scrapers, if practicable, and from the velocity of the current on the bars above Middletown, there seems no reason why they should not answer the purpose, except where the bottom is gravel, in which case it will probably be necessary to use an excavator.

On the bar at the mouth it is uncertain what would be the action of the current on the material loosened by the scrapers. At the mouth of the Mississippi the current is always in one direction, while at the mouth of the Connecticut we have the alternate ebb and flood currents from the tides of the sound. Still I think it advisable to try the scraper in this case.

It is possible at once to make a trial of the scraper in the Thames river, and from the success in removing the sand-bars on the upper Mississippi, I would recommend the immediate construction of a scraper to be used on the Thames. Even if it should not fully answer the purpose, it will have the effect of loosening the material to be dredged, as well as diminish its amount. The velocity of the ebb current in the Thames was found to exceed three feet per second. Should this recommendation be approved, I request to be furnished with any detailed information in possession of the department, not contained in General Warren's report, in relation to the use of the scraper, and, if possible, authority to construct a scraper here by day's work, and employ a suitable tug-boat, without the delays incident to the system of advertising, making contracts, &c. In a matter of this kind, and in this locality, a satisfactory contract cannot well be made.

In regard to the estimate for dredging the bar at the mouth of the river, it was based on the assumption that it was desirable to obtain a ceannel 100 feet wide and 8½ feet deep at low water, this depth corresponding to the depth proposed to be obtained on the bars above Middletown at extreme low water. The present depth of water on the bar at the shoalest place is 7 feet, as near as could be ascertained; but this occurs only for a short distance. I assumed, then, that the prism to be excavated would be 2,000 feet × 100 feet × 2 feet = 14,815 cubic yards, say 15,000 cubic yards.

ESTIMATE.

15,000 cubic yards, at 50 cents per yard	$7,500 00
Contingencies	2,500 00
Total	10,000 00

It would be desirable to obtain a deeper channel, but from my inquiries at Hartford before the survey was commenced, the great desideratum and immediate want seemed to be the improvement of the river between Middletown and Hartford; so much so, that I had some hesitation at first about presenting an estimate for the improvement of the bar at this

time. I inclose herewith a revised estimate for excavating a channel over the bar; first to obtain a depth of 9 feet at low water; and second, to obtain a depth of 12 feet.

I am, general, very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers, Brevet Colonel United States Army.

Brevet Major General A. A. HUMPHREYS,
Commanding Corps of Engineers U. S. A., Washington, D. C.

Estimate of cost of deepening the channel on the bar at the mouth of the Connecticut river, by excavations.

First. To obtain a channel 200 feet wide and 9 feet deep at low water.

The present depth on the bar at its shoalest place being 7 feet, we may assume that the prism to be excavated is 2,000 feet × 200 feet × 2 feet = 800,000 cubic feet or 30,000 cubic yards, the extremities of the 2,000 feet channel being now in 9 feet of water.

Cost of employing chain-bucket machine and scows per week, including breakages, $600; capacity of machine per day, 400 cubic yards; assuming an average of three working days per week, we have 1,200 yards per week, at 50 cents per yard = $600.

30,000 cubic yards, at 50 cents per cubic yard	$15,000 00
Contingent expenses, supervision, &c.	2,500 00
Total	17,500 00

Time required for one machine, 25 weeks or 6 months.

Second. To obtain a channel 200 feet wide and 12 feet deep at low water.

The prism would be 200 feet × 3,125 feet × 5 feet = 3,125,000 cubic feet, or 116,000 cubic yards, nearly, at 50 cents per cubic yard	$58,000 00
Supposing the work to be done in one season, there would be required four machines for six months; add to the above, contingencies, supervisions, &c.	4,000 00
Total	62,000 00

Under favorable circumstances the capacity of the machine is greater than as above mentioned. The prism assumed exceeds the amount actually required to be excavated; but this assumed excess is equalized by the quantity which the machines will necessarily excavate below the depth required in order to secure that depth.

Respectfully submitted.

D. C. HOUSTON,
Major of Engineers, Brevet Colonel U. S. A.

ENGINEER OFFICE U. S. A., *Newport, R. I., January* 27, 1868.

The amount estimated, $17,500, for excavating a channel 9 feet deep at low water would, according to the estimate of Major H. C. Long, (and these estimates would not be exceeded here,) operate a scraper for seven months.

P 7.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, January 15, 1868.

GENERAL: I have the honor to submit herewith a report of a survey of Block island, Rhode Island, for a breakwater or harbor of refuge, made in pursuance of the act of Congress approved March 2, 1867.

Block island is situated about 14 miles to the east of Montauk Point and 12 miles south of Point Judith. It comprises an area of about 10 square miles, and has a population of about 1,400 souls. This population subsists principally by farming and fishing. The island is entirely destitute of any harbor, and has been the scene of numerous disasters to our commercial marine. The total loss in the year 1857 was about $150,000. The only boats now in general use in communicating to and from the island are open sail-boats, the largest of which does not exceed 36 feet in length. The usual landing place for these vessels is at the point marked "Sand's landing" on the Coast Survey chart. When at the landing these boats are protected from the action of the sea by rows of poles driven into the sand, which in ordinary weather break the force of the waves. At times, however, it becomes necessary to haul the boats on the shore.

The object of the survey was to determine the best manner of forming an artificial harbor, and instructions were given to the surveyor to conduct the survey with a view to that object, and to collect all available information in regard to the necessity, practicability, and extent of such a work.

He was also directed to pursue his investigations with a view, first, to secure a harbor which should suffice for the needs of the inhabitants of the island—*i. e.*, a secure anchorage for the boats employed in fishing, and a place where steamboats and sailing vessels of light draught could land freight and passengers. Second, to make a harbor which should be a harbor of refuge for vessels plying along the coast, including the great number of vessels which seek a harbor on these shores.

It was considered that these instructions would cover the whole field of inquiry contemplated by the law. In addition to an actual survey of those points where it was possible to make an artificial harbor, recourse was had to every source of information regarding the utility of a harbor at Block island, both for local and general purposes. The benefits of a harbor at Block island for local purposes are as follows: First, it would enable a continuous communication to be kept up between the island and the main land, which does not now exist, owing to the impossibility of landing boats a great portion of the time; second, steamboats and other vessels would be able to land their cargoes and passengers at a wharf, instead of in small boats as at present; third, the islanders would be able to employ a larger class of vessels in fishing than is now possible, because at present they are obliged to haul their vessels on the shore during storms; fourth, a great impulse would be given to the trade of the island by the facilities thus afforded. The following are advanced as reasons why the government should furnish a harbor for local purposes: First, it will foster the fishing interests in that locality, which are capable of being developed to a great extent, thus increasing the amount of cheap food which finds its principal market in New York city and other ports on the main land; second, there being now one light-house on Block island and another in contemplation, additional facilities are desirable for communicating with and supplying them;

Third, it will furnish a harbor of refuge for a large class of coasting vessels, and thus diminish the number of maritime disasters so numerous on this coast. A very large portion of the coasting vessels, including coal schooners, pass to the south of Block island, and are not provided with charts or pilots, and are averse to seeking a harbor on the main coast, as at Narragansett bay, but desire a harbor close at hand, and where the changes in the weather can be promptly observed and taken advantage of. These are the principal reasons why the government should take steps in this matter, taking the narrowest view of the question. If we look forward to a time when Long Island sound will be the principal route of steamers bound to New York, Block island is an excellent point for a pilot station, which it could not be without a harbor. By increasing the capacity of the harbor we not only secure the advantages above mentioned, but we extend the benefit of it to all classes of vessels, and the average number of vessels passing within 15 or 20 miles of Block island is estimated at 200 per day.

The accompanying report of Major G. W. Dresser contains all the facts bearing on this question that can be collected, and gives all the reasons which point to the necessity of the harbor as called for by the law authorizing the survey, and discusses the matter in its relations to the defense of our coast. I do not attach so much importance to this view of the subject as to the commercial benefits to be derived from the work, though a harbor at Block island would be very convenient for our navy in case of war with a naval power, and would be easily defended. Regarding the matter, however, *solely* from this point of view—*i. e.*, its relations to the defense of our coast—it would not be policy to form a harbor of refuge at this point, owing to its isolated position and the possibility of its falling into an enemy's hands and adding materially to his strength; but as the demands of commerce are paramount, if they should be deemed of sufficient importance to warrant such a work, it should be done, and then the harbor would become an element in the system of naval defense, and it would become necessary, at least in time of war, to defend it by fortifications in order to prevent an enemy from taking possession of it and fortifying it for his own purposes. If securely held by us, it would, as stated before, be a point in our favor, as affording a convenient place of rendezvous for our cruisers. Two methods have been suggested for accomplishing the object in view: one, by cutting a channel to connect the pond in the center of the island with the ocean; and the other by the construction of a breakwater to the east of the island, in the manner indicated on the accompanying drawing, or similar to it. Both plans have been fully investigated, and it is believed that the last named is the correct one. Everything goes to show that if a channel were to be cut through the sandy strip separating the pond from the ocean, that it would eventually be filled up by the action of the sea; but supposing it otherwise, it would be a difficult matter for a sailing vessel to effect an entrance into this necessarily narrow channel during storms, which would be the very time when they would need to use it. Moreover, this pond is frozen over in winter, the season when a harbor is most necessary. Besides, as there can be no doubt that this channel would be filled up by the action of the sea, there would be a constant expenditure necessary to preserve the required width and depth. This question of connecting the pond with the ocean has been investigated because it has been a favorite notion with some of the inhabitants of the island.

The other method of forming a harbor, viz: by the construction of a

breakwater to inclose the roadstead on the eastern shore of the island, involves no uncertainties. It is principally a question of expense, and the amount which can be appropriated must depend on the amount of benefit to be derived.

A plan and sections of a breakwater are furnished with this report. *This plan is not meant to be exact, nor is it offered as the best solution of the case*, for I presume that a work of this magnitude would not be undertaken until after attentive consideration by a competent board of engineers; but it is offered as the basis of an estimate, it being supposed that such a work will cost as much as any work which would be designed.

The breakwater which is indicated on the drawing is 3,000 feet in length, and effectually protects the harbor from all injurious winds. The worst storms are from the east and southeast, and during storms from these quarters the roadstead is untenable for vessels of any class.

The estimated cost of this breakwater, including a light-house, is $1,500,000. It is proposed to construct it in a manner similar to the Delaware breakwater. The cross section of the breakwater below low water is 30 feet wide at the top, with a slope of one upon three on the sea side, and one upon one on the harbor side, the stones used upon this part of the work, except on the top and outer slope, to be of all sizes, not less than one ton; those excepted to be not less than three tons. This to be surmounted by a dry wall of the dimensions indicated on the drawing, the stones used to be less than three tons, and cut to specified dimensions, and fastened together on the exterior by clamps of galvanized iron. These details have been assumed only as the basis of an estimate.

In regard to the practicability of the work, it does not seem more difficult than the Delaware breakwater. To obtain the material it will be necessary to depend on the quarries of the mainland. The greater portion of the breakwater can be formed by vessels unloading their cargoes on the spot. In ordinary weather vessels can lie in the roadstead with perfect safety, though there will be times in the earlier progress of the work, at least, when much time will be lost. It is proposed to commence the work near the shore, and push it to completion (as to cross section) as it progresses. In this way a small harbor will soon be formed, which will afford shelter to the vessels engaged on the work. In this way also, should the work be from any cause suspended, *that already done will be of benefit proportional to the expenditure.* If, therefore, there should be any hesitation or difference of opinion in regard to the propriety of such an extensive work as has been described, but none in regard to the minor question of local benefit, the latter object can be attained, and the more important question left open for future investigation by an experienced board of engineers. I would by no means recommend the construction of a breakwater at Block island without due consideration, and this report is intended simply to communicate the results of the survey, and all the information that I have been able to obtain bearing on the matter. At the same time, these plans are presented to show how the object may be accomplished should it be deemed of sufficient importance. The views herein presented, as well as those in the accompanying report, have resulted not simply from general considerations, but from consultations with seafaring men, and shipping merchants in New York city and elsewhere, who have all concurred in the opinion that a harbor at Block island is greatly needed, as tending in a great degree to diminish the dangers of navigation on this portion of our coast.

In compliance with circular No. 11, dated engineer department, Washington, June 10, 1867, I have to report as follows:

1. Result of survey with plan adopted, with items of expenditure. Answer. As indicated in the foregoing report and accompanying documents.

2. Amount required for the entire and permanent completion of the work. Answer. $1,500,000.

3. Amount that can be profitably expended during the next fiscal year. Answer. $300,000. Should local benefit only be considered, $150,000

4. Block island is located in the 29th collection district.

5. The nearest port of entry is Newport, Rhode Island.

6. Amount of revenue from customs collected at Newport, Rhode Island, during the fiscal year ending June 30, 1867, $11,884 05. Average amount for the five preceding years, is $29,189. It is to be observed here that the work in contemplation is not designed for the benefit of Newport especially, but for the general interests of commerce, which finds its principal center in New York city.

7. As far as practicable, what amount of commerce and navigation would be benefitted by completion of this work? Answer. It is difficult to answer this question more definitely than by referring to the body of the report. It may be said in general that all vessels bound to or from the city of New York, and the entire coasting trade north of the Chesapeake, would be benefited more or less by a harbor of refuge at Block island.

The following drawings accompany this report, viz: Map No. 1, giving the general outline of the island, enlarged from the Coast Survey map. No. 2, drawing showing the outlines and soundings of a pond in the center of the island, which it has been proposed to convert into a harbor by cutting a channel to connect it with the sea. No. 3, drawing showing, on a large scale, the roadstead now principally used as an anchorage, upon which is indicated a plan of a breakwater, designed to make this roadstead a secure anchorage for vessels of all classes in all weather.

There are also sketches showing the position of Block island and its relation to the adjacent shores, and a plan and section of the breakwater at Plymouth roads, on the southern coast of England.

I am, general, very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers, Brevet Colonel U. S. Army.

Brevet Major General A. A. HUMPHREYS,
Commanding Corps of Engineers U. S. A., Washington, D. C.

P 8

NEWPORT, RHODE ISLAND, *November* 1, 1867.

COLONEL: I have the honor to submit the following detailed report of survey at Block island, with reference to the location of a work to secure a harbor of refuge at that island, supplementary to my report of September 10, 1867.

According to your letter of instructions, (a copy of which is hereto appended, marked A,) the object desired is to obtain at Block island a harbor of refuge available for all vessels in all weather, and, if compatible with the nature of the case, to so locate the necessary work therefor as to meet not only the necessities of the islanders, but what is of primary and far greater importance in every great national work of this kind,

the demands of a true system of naval and military defense of our coast and the requirements of our merchant marine.

Block island, with a good harbor of refuge, would be, from its position, a most important point in defending an extensive portion of our coast in time of war. Situated 12 nautical miles, about south-southwest, from Point Judith, and 14 nautical miles east-northeast from Montauk Point, or the easterly end of Long island, it is the key-point to the entrance to Long Island sound.

The general principles of sea-coast defense require certain conditions to be fulfilled to insure and assist the efficient and harmonious action of the army and navy. Among the most important of these are the following, viz: Large cities and towns must be covered from attack. There must be provided harbors of rendezvous and ports of refuge—complete protection for the main lines of intercommunication, especially by water, by the closing or defending channels of approach against an enemy, and preventing the great avenues of interior navigation from being blockaded at their entrance to the ocean, thus insuring the expeditious concentration and transfer of troops, and unfailing distribution of supplies of every description, as well as preserving unimpaired the interchanges of domestic commerce, even during periods of most active external warfare.

In applying these principles to the military and naval defense of our coast from New York to Cape Cod, it is easily seen that Block island, with a harbor of refuge available at all times, would be a point of the utmost importance. The defense of the entrance to Long Island sound is not only the defense of the whole southern coast of Rhode Island and Connecticut, but of the city of New York.

The removal of the obstructions in Hell Gate, at New York, is only a matter of time, either by the action of the general government or by private enterprise. The increase of commerce will in time demand the use of this shorter and more natural channel to the east. The growth of the city of New York itself, together with the improvements in Harlem river and Spuyten Duyvel creek, now projected, whereby the commerce of the North river can pass into the sound or the East river without going around the south end of Manhattan island, will transfer or extend the shipping interests from the extreme southern point of New York city to the more northerly portions of the island; all of which will tend to increase from year to year the importance of the sound entrance to that port, and the true place to defend this highway of the commerce of the world will be at its very entrance from the sea.

By reference to the accompanying map (No. 4) it may be seen that in case of foreign war the whole sound and the interior lines of communication from New York to the east, by railroad and by water, to the various ports along the coast and rivers of Connecticut, Rhode Island, and the southern coast of Massachusetts, would be completely covered from naval attack by an adequate naval force stationed on a line drawn from Nantucket to Long island.

But to *hold* this line some central point is needed, where this force could concentrate for supplies or for shelter in very heavy storms which would endanger the safety of the fleet. A harbor of refuge at Block island would satisfy this need. Being central with reference to the line of naval defense, the fleet would not be obliged to disperse and go to sea or run up Long Island sound to shelter themselves, but could concentrate there, where they would be most available for repelling any advance that might be attempted on any part of the line, and any stress of weather that would force our fleet to seek refuge would at the same time force the enemy to put *to sea to avoid* a dangerous lee shore.

what it then was. The introduction of steam, of iron-clads and mo
and of heavy-calibered long-range ordnance, has changed the re
between attack and defense most materially. No land force co
landed by an enemy on the shores of Block island without grea
save in the calmest weather, when all the steam fleet could be u
the greatest advantage; and the topographical features of the
itself are such as to admit of a most stubborn and successful opp
by comparatively few men to any party that might by accident s
in landing. Hence the old objection of some to government e
tures at this point is no longer a potent one, and a harbor of refug
is a most important accessory to the defense of an extensive line
coast, which controls at once several of the most important wate
nels of internal intercommunication, viz: Narragansett bay, with
dence, Fall River, and Taunton rivers; the Thames river, the Co
cut river, the East river, with all the important harbors, bays, an
steads of Long Island sound, and what is destined in time to
the most direct and important entrance to the port of New Yo
commercial center of the country.

The advantages of a harbor of refuge at Block island to our m
marine cannot be accurately calculated. After careful inquiry,
been unable to obtain exact data as to the actual amount of prop
the number and value of vessels that annually pass this point
numbers of them passing and repassing many times in the cours
year; but from the best information that I can get I conclude t
vessels per day is a low estimate for the average daily number th
within 15 or 20 miles of this point, (I have counted 150 vessels i
there at one time,) every one of which would be liable to be b
in one way or another by a harbor there. One of the greatest
ances and injuries to which our merchantmen are subjected,
detention incident to coming on this coast in bad weather.
vessels coming from sea or along the coast are met in this vicini
northerly storm, unable to make Narragansett bay, they are oblige
to put to sea again or run for the capes of the Delaware for sh
avoid the dangers of the coast. This causes long delays and of

anchor in safety till the storm was over, and then proceed at once to their destination.

There is not a vessel of any class or character, not a pound of freight of any kind, nor a man passing back and forth in our coasting trade, but what would be benefited by a national work here. The rates of insurance and of freights past this point should be reduced by it, as the hazard of transportation would be greatly lessened. The annual saving of property in vessels and cargoes that would result from a harbor of refuge at Block island is variously estimated by different persons, but the testimony of some of our most experienced and reliable merchants and ship-owners places the annual saving of property that would result from this national work at sums varying from $100,000 to $500,000. From the year 1854 to the year 1868 the amount of property stranded on Block island amounted to $378,050. The vast coastwise trade of the North Atlantic States in all its connections, the merchants throughout the entire country, the underwriters, the manufacturers, the coal and iron trades, upon which the industry of New England depends so largely, and the thousands of lives engaged in navigation and passing from point to point by water, all would be benefited by this work. It is truly a national interest. There are no local interests that are anything compared to the general interests. Though a small island, at sea, as it were, at times cut off for days from communication with the main land, still their local interests, small though they are, have been most seriously affected from the fact of having no harbor. There are about 1,400 inhabitants on the island. Their occupation is farming and fishing. The agricultural products of the island amount to about $290,000 per year, and the fish caught, including both salt and fresh, will not fall far short of $60,000 worth per year, making total products of the island, from farming and fishing, $350,000. The agricultural exports are as follows, viz:

20,000 bushels oats,	12 tons wool,
3,000 bushels corn,	250 cattle and horses,
10,000 bushels onions,	1,000 sheep,
5,000 bushels potatoes,	1,000 swine,
4,000 dozen eggs,	2,000 tons paving stone,
100 tons poultry,	25 tons black sand.

The amount of fish of all kinds exported yearly, viz:

5,000 quintals dried cod,	20 tons fresh eels,
200 tons fresh blue fish,	15,000 bushels oysters,
50 tons fresh cod,	350 barrels fish oil.

The Block Island cod fisheries amount to about $25,000 per year. All their boats are of peculiar construction. They are all open boats—that is, with no deck, the largest being able to carry about 10 or 12 tons. They are constructed in such a way, from necessity, that they can be easily hauled upon the shore in storms, and hence are small and light. The amount of codfish caught by the inhabitants of the island from 1789 to 1866 amounted to 355,000 quintals, which, at an average price of $4 50 per quintal, gives $1,597,500.

At the time that our fishermen were receiving bounty, the Block islanders were deprived of any bounty from the fact that their vessels were not of the required tonnage, it being impossible for them to keep any vessels there constructed in such a way as to give the dimensions required for the minimum tonnage under the law, owing to there being

fires, to add their quota to the supply of cheap food for the c
Hence, although the local interest is small compared to the great n
benefit to commerce and trade, yet whatever local advantage may
from the construction of a national work there, the islanders are
ing of it as compensation for past inequalities to them in the wo
the general law.

Out of the entire population of 1,400, men, women, and childi
island furnished 50 men as volunteers for the recent war, abo
quarter of whom laid down their lives in the country's cause.

Another consideration of importance is this: A harbor at thi
would in time make it one of the most important *pilot stations*
coast, it being so directly on the line of vessels coming in bound
various ports to which these waters are the entrance, and it wo
station such that in the most severe weather they could find
shelter and safety.

The interests of our commerce demand a national work here th
be permanent in its character, and of such magnitude and arran
in its details that it shall make a *safe anchorage from all storms
all times.* From a thorough and careful examination of the entire
as stated in my preliminary report, but two points present the
where attempts might be made, with any reasonable hope of suc
secure this object. These two points are indicated in the accom
map of the island, (Map No. 1,) one on the west side, at which
been proposed to make a "cut into the Salt pond," more for lo
for general use; and the other on the east shore, near "the la
where a breakwater could be constructed that would satisfy ev
dition of the problem.

As the works at these two points would of necessity be of
different character, I propose to consider each separately:

1st. *The "cut" into the Salt pond.*—The accompanying map
shows the contour and soundings of the pond, together with th
tions of the shore-lines of the island on the east and west that lie
the pond. It will be seen that but a narrow strip of *sandy bea*

is the narrowest, to the point on the west shore where the land is the narrowest between the pond and the sound.

2d. On the east or sea-side of the pond the soundings increase more gradually, up to a certain distance from the shore towards the middle of the pond, than they do on the west; but on both sides where the water begins to deepen rapidly as you go towards the center, the increase of depth is very abrupt.

This would naturally be the case, for the greater force of the *sea* waves would throw the sand further into the pond, or rather into the supposed channel, and give more shallow water on the east than on the west side. At the present time, in *heavy* storms and high tides, the sea breaks over the beach on the east side into the pond, cutting off communication for the time between the north and south portions of the island, along this side; and every such flow of water over the beach carries additional sand into the pond.

At the point on the west side, marked "Breach," the islanders make a cut, which has to be opened several times a year, for the purpose of drawing off the water from the pond into the sound sufficiently to keep the road dry which runs along the east shore of the island from north to south, between the pond and the ocean. This "breach" is but a small ditch dug in the sand, which fills up at the mouth or west side a little higher than ordinary high-water mark during the first heavy westerly blow that occurs after it is dug out. At the time I examined it this "breach had been opened," about two weeks before, but was then filled up on the sound end above high-water mark by the action of the water. The pond is fed by the water-shed of the greater portion of the island and by springs, and undoubtedly, to a certain extent, by salt water forced through the sandy beaches on either side of it, as the water is salt or "brackish;" and during extreme low tides I noticed numerous little streams, varying in size, running down the sea beach into the sea. These little streams are not so salt as the sea, but about the same as the pond water to the taste. These are seen at the point on the east beach, where the distance between the pond and the sea is the shortest.

It has always been a favorite idea of some of the islanders to avail of this pond as a harbor, by making a "cut" on the west into it from the sound. But, from all that I can learn, nothing of the kind has ever been attempted, except to "open the breach" for the purpose referred to above. Attempts of a similar nature have been made with the ponds on the south shore of Rhode Island, but have failed.

At Charlestown, Rhode Island, a company was chartered by the State, and operations commenced by them, to connect the Charlestown pond with the sound. But they found that the excavation filled up as fast as it was made, and the enterprise was abandoned.

In order to make a harbor of the "Salt pond" at Block island, the cut should be made, if at all, at a point further south than "the breach," as indicated on Map No. 2, for at that point the distance from the south to the deepest water in the pond is the shortest. To make a channel available for all purposes the cut should be made at least 25 feet deep below mean low-water mark, and the width of which the nature of the ground will admit is not over 650 feet.

The estimates for this excavation are made upon a basis of 25 feet deep, 633 feet average width, and an average length at the bottom of the cut of 2,425 feet, giving $996{,}104\frac{46}{100}$ cubic yards of excavation.

The profiles of this cut are shown on the accompanying map of the pond, (Map No. 2.) "Profile A B" shows the profile of the south side of the cut, and "Profile C D" shows that of the north side.

sand and sediment to deposit at different points in the channel, ing to the direction and stage of the tide. Bars would form at t of the channel, and the bottom of the sound being sand, the would ultimately fill up on the sound end in spite of all precau protect it. The same causes that fill up the breach would fill and a constant expenditure would be necessary to dredge it out all indications nature has filled up a channel much larger than proposed above, and the same causes would operate again to time any cut that might be made there. In all probability th occur at the first heavy storm after the cut was completed. A at the soundings of the pond will show the exceedingly irregu formation of the bottom of it, and that only a small portion of of the water could be used for anchorage without continual and trouble from getting aground.

The prevailing storms from which the most shelter is requ from the east. But this would be a head wind to beat through channel to get into the harbor or pond, and if blowing hard it impossible to beat in at all; while, if in the pond, it would be difficult to get out with a west wind.

There is one point which would be of vital importance if it become necessary to use the pond as a harbor in naval defense freezes completely in winter; hence I conclude that although a c be made and kept open at a large expense, it would not be ava all times, either for ingress or egress, and that the advantages g the work would not be commensurate with the expense, par when compared with what might be obtained at the other poir east side of the island by building a breakwater into the bay.

I submit herewith a map of the bay on the east side, showing t line, the depth of water in feet, and the character of the bott pared from actual survey while there. The bay is sheltered by from all but easterly storms. The bottom is excellent holding being smooth and free from rocks; it is clay with sand on the of it, and slopes off very gradually from the shore. The poi

There are no rocks that would require to be moved, except, perhaps, the one marked A, known to the islanders as the "Blue Bird," and two at the "Point of the Reef," marked B. These are not large, being about 10 feet high and 15 feet long by 8 feet wide, and have respectively five feet and three feet of water on them at low water. The general plan and cross sections of a work that would answer all requirements is shown on map No. 3, and also the location thereof as proposed. This plan is submitted as a basis of estimate. It is proposed to make the substructure about 3,000 feet in length, with a cross section of 30 feet at the low-water mark, with a slope of one upon one on the inside, and one upon three on the sea side.

The depth of water at 3,000 feet from shore, on line indicated, is eight fathoms, (48 feet.)

The substructure, or that portion below low-water mark, would be built in the usual way, by anchoring vessels on the line and throwing the stone overboard. Upon this, when brought up to low-water mark, a superstructure of solid masonry, carefully laid and securely clamped, to be built 12 feet high, 15 feet across the top, and 20 feet at the base, the whole length to be terminated by a small light-house at the north end.

The following is the estimate of cost upon this basis:

Substructure—	
Amount of stone required, 229,630 cubic yards; or, estimating 1½ ton per yard, 344,445 tons, at a cost per ton delivered of $3	$1,033,335
Superstructure—	
24,111 cubic yards of masonry, at $15 per yard, laid	361,665
Light-house	30,000
Piles for marking line of work, clamps for superstructure, inspectors, and incidentals	20,000
Total cost	1,445,000

By reference to accompanying map, (No. 3,) showing location of the work, it will be seen that perfect protection would be afforded from all troublesome winds, and accommodations for anchorage of several hundred vessels. Winds from the north, south, and west would be broken by the island itself, while the breakwater would protect from all easterly winds.

The "southeasters" throw in the heaviest swell, and the force of this would be broken somewhat by the reef or shoals off "Old Harbor Point," and would strike the work in the general direction of its length. An east wind would test the masonry most severely, as its action would be nearly normal to the work; but by a proper arrangement of the outer slope the force of the waves would be so modified that, if properly constructed, the superstructure would stand without serious damage. The northeast storms do not create so heavy a sea here as at many points on our coast, being broken in their force by Cape Cod and adjacent islands. In fact, the experience of the islanders is, that it is very seldom necessary to haul their boats on shore in northeasters.

I do not think that any trouble would ever arise from filling up behind the pier by the action of the water depositing sand and sediment within it, from the fact that a short wall, shown on the map, at the landing, extending into the water about 100 feet, has been built about 25 years,

the vessels in our coasting trade, from Maine to Georgia, would be
fited, each in proportion to the frequency of their presence in th
of the coast. As a harbor for naval purposes in time of war, it
be easily defended by batteries thrown up on the high ground at
side of it.

The construction of the breakwater would not be attended l
unusual difficulties, the bottom being firm and solid; and, after a
of the shore end of the work had been completed, delays incid
heavy weather would diminish as the work progressed. As st
my preliminary report, the island itself could furnish no stone
structure; but large quarries abound on the shores of the neigh
mainland in Connecticut and Rhode Island, where stone co
obtained, put on board vessels, and transported to the point r
more cheaply, probably, than it could be got out and put in
rock existed on the island, from the fact that quarries already
ation would have all the facilities for getting out and handli
material. The time that would be required to build the work
depend altogether upon the number of vessels employed and the
of the annual appropriation.

While engaged in making this survey I kept a record of the r
fall of the tide, and herewith submit the record in tabular form, t
with a description of the tide-gauge used.

The tide was taken once an hour during the day, principally
purpose of reducing the soundings to mean low water. There b
permanent mark at the landing known as low-water mark, I ass
point as near as could be determined from the testimony of m
from their constant daily presence, would be likely to be informe

Having erected a platform over the large rock at the end of t
running into the water near the landing, I attached the tide-ga
pile driven at the corner of it, placing the zero of the tide-gaug
point assumed, as above.

At the close of the survey I determined the difference in level b
the assumed and the actual average low-water mark for the time ob

on Map No. 3 as "Bench Mark U. S." The average daily rise and fall for the 31 days recorded was three feet two inches.

I also kept a record of the thermometer during the progress of the survey, taken three times each day, viz: 7 a. m., 1 p. m., and 6 p. m. The thermometer used hung in the shade, on the piazza of Mr. Alfred Card's hotel, the best and most convenient point to be found. The record at 7 a. m. was undoubtedly too high, as there was a strong reflection from the water; but the record of the other two times is as correct as could be obtained. I submit herewith a tabular record of these observations.

Much of the time was very stormy or foggy, which interfered seriously with the rapid progress of the survey.

On the 2d of August I had an opportunity to witness one of the severest gales, from the southeast, that had been seen on this coast at this season of the year within the memory of the oldest of the inhabitants.

This gale, and its effects upon the water of the roadstead, was of great advantage to me in determining the direction and extent of the work required to accomplish the object desired, as well as the starting point on the shore. Although the fury of the gale prevented the use of any accurate instruments, still, by establishing ranges on the shore at different points, I was enabled afterwards, by actual measurements, to locate the limits of the work required; and I am fully satisfied that the location and extent (in length) of the work as laid down in plan on map No. 3 would meet all the requirements even in gales of this nature, and that a work materially shorter than the one suggested would be found of far less value to our commerce than this, in a southeast storm, while in a gale from the east the shelter afforded would be very much less, as in that case only that portion of the roadstead between the breakwater, the shore, and an east and west line through the north end of the work, would be protected; and in case the work was a short one, it will be seen, by reference to map No. 3, that the necessary depth of water would be too near the work for convenience in getting in and out.

The survey was commenced on the 20th day of July, 1867, and completed on the 6th day of September, 1867.

Every facility was afforded me by the people of the island, in getting information, &c., necessary for my report.

Respectfully submitted.

GEORGE W. DRESSER,
Assistant Engineer in charge of Survey.

Brevet Colonel D. C. HOUSTON,
Major United States Engineers, Newport, Rhode Island.

List of accompanying papers.

A. Letter of instructions from Colonel D. C. Houston, United States engineer.

B. Tide-gauge record.

C. Record of thermometer, wind and water.

D. Copy of letter from collector of customs at Newport, Rhode Island, in answer to inquiries regarding cod fisheries at Block island.

E. Copy of letter from Nicholas Ball, esq., to collector of customs at Newport, Rhode Island, regarding products of Block island.

F. Statement of products, and amount thereof.

G. List of vessels wrecked on Block island from 1854 to 1868, with amount of loss.

Newport, Rhode Island, July 11, 1

DEAR SIR: As soon as you can make your arrangements, I that you visit Block island for the purpose of making a survey view to the location of a breakwater which shall form an artifici bor. There are two objects in view in making this survey:

First. To secure a harbor which shall suffice for the needs inhabitants of the island—*i. e.*, a secure anchorage for the boats em in fishing, and a place where steamboats and sailing vessels o draught can land freight and passengers.

Second. To make a harbor which will be a harbor of refuge f sels plying along the coast, and including the immense number sels from all parts of the world which seek a harbor on these sho

I am of opinion that both these objects can be accomplished same time, or rather that what is done towards accomplishing th may be so much towards fulfilling the requirements of the secon occurs to me that a good harbor at Block island is a great desid for the benefit of our commerce, and also that any approximatio harbor there will be more or less of benefit in the same direction.

It will be necessary for you in the first place to make a th preliminary examination of both eastern and western shores island, and, after deciding upon the most suitable point for the l of a breakwater, to make a particular examination of the sho hydrography in that vicinity, in order to make a plan of the nec work and to exhibit the character of the harbor to be secured.

It is possible that two breakwaters may be desirable, one eastern and one on the western side.

My impression is that the eastern one is the most important a involve the greatest expense, and that perhaps one can be const on the west side at a comparatively small expense, which, howev be of great service.

These are points, however, I desire you to examine into.

The necessary instruments, stationery, &c., will be furnished fr office. It is understood that all the assistance you may need in th

B.— *Tide-gauge record at Block Island, Rhode Island, from August 8, 1881, kept by George W. Dresser, assistant engineer in charge of survey.*

Date.	HOURS A. M.							HOURS P. M.						Daily rise and fall.
	6.	7.	8.	9.	10.	11.	12.	1.	2.	3.	4.	5.	6.	
	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
August 8	0 2	—0 1	0 2	0 0	0 2	0 9	1 3	1 10	2 1	2 4	2 0	1 5	0 10	2 6
9	0 11	0 5	0 0	0 0	0 2	0 6	0 10	1 5	1 11	2 2	2 3	2 1	1 6	2 3
10	1 5	0 10	0 4	0 1	0 0	0 2	0 7	0 11	1 6	2 1	2 6	2 4	2 3	2 6
11	1 9	1 4	0 10	0 4	0 0	—0 2	0 4	0 8	1 2	1 10	2 4	2 8	2 5	2 10
12	2 0	1 9	1 4	0 7	0 1	—0 2	0 0	0 3	0 8	1 6	2 1	2 7	2 10	3 0
13	2 4	2 3	1 11	1 4	0 6	—0 1	0 0	0 2	0 7	1 2	1 11	2 7	2 11	3 0
14	2 8	2 9	2 5	1 10	1 0	1 3	—0 1	0 0	0 2	0 8	1 6	2 2	2 10	2 11
15	2 4	2 9	2 7	2 3	1 8	0 7	0 1	—0 2	—0 1	0 5	1 0	1 8	2 6	2 11
16	2 1	2 6	3 0	2 11	2 6	1 6	0 9	0 1	0 0	0 4	0 10	1 0	2 0	3 0
17	1 10	2 3	3 2	2 11	2 7	1 7	0 8	0 1	—0 1	0 0	0 4	0 11	0 7	3 3
18	1 0	1 9	2 6	3 0	2 10	1 11	0 10	0 4	0 1	—0 2	0 2	0 3	0 7	3 2
19	0 4	1 0	1 10	2 9	3 1	3 0	2 5	1 5	0 2	—0 2	—0 3	0 0	0 1	3 4
20	0 0	1 9	1 5	2 3	2 9	2 11	2 7	2 0	1 1	0 4	—0 1	—0 3	0 0	3 2
21	—0 2	0 2	0 10	1 4	2 2	2 9	2 11	2 8	2 0	1 1	0 4	0 2	0 0	3 1
22	—0 3	0 0	0 4	0 11	0 5	2 2	2 10	3 0	2 7	2 0	1 1	0 6	0 3	3 3
23	—0 0	0 3	0 4	0 8	1 3	1 4	2 9	3 2	3 3	3 0	2 5	1 4	0 8	3 3
24	0 6	0 3	0 0	0 2	0 5	0 10	1 9	2 6	3 0	3 2	2 11	2 4	1 6	3 2
25	0 11	0 6	—0 1	—0 3	—0 3	0 7	1 2	1 11	2 7	3 1	3 2	2 10	2 3	3 7
26	2 1	1 5	0 7	—0 4	—0 8	—0 7	—0 2	0 7	1 5	2 5	3 1	3 0	2 9	3 9
27	2 10	1 4	1 5	0 4	—0 6	—0 8	—0 7	—0 2	0 6	1 5	2 5	3 4	3 5	4 1
28	3 2	3 4	2 9	1 6	0 4	—0 4	—0 8	—0 4	—0 2	0 9	1 9	3 2	3 6	4 2
29	3 4	3 7	3 9	2 11	1 8	0 7	—0 2	—0 8	—0 6	0 3	1 0	2 1	3 3	4 0
30	2 5	3 5	3 8	3 6	2 8	1 6	0 3	—0 6	—0 8	—0 8	0 5	1 1	1 9	4 4
31	1 5	2 6	3 2	3 6	2 11	2 10	0 8	—0 5	—0 8	—0 8	—0 5	0 2	1 3	4 2
Sept. 1	1 0	1 6	2 6	3 2	3 9	3 3	2 3	1 0	0 1	—0 1	—0 1	0 6	1 0	3 10
2	0 2	0 11	2 0	2 9	3 2	3 3	2 7	1 8	0 5	—0 1	0 0	0 1	0 7	3 4
3	0 0	0 6	1 4	2 0	2 11	3 1	3 3	2 7	1 7	1 0	0 7	0 3	0 7	3 0
4	0 0	0 6	0 11	1 7	2 0	2 8	3 1	2 11	2 1	1 6	0 10	0 6	0 4	2 9
5	0 2	0 5	0 6	1 0	1 6	2 0	2 8	2 11	2 7	1 10	1 4	0 11	0 4	2 9
6	0 5	0 3	0 6	0 9	1 0	1 7	1 11	2 1	2 4	2 3	1 9	1 4	0 9	2 1
7	0 6	0 5	0 4	0 6	0 9	1 0	1 7	1 11	2 2	2 4	2 1	....(*)...	....(*)...	2 0

* Gauge taken down.

NOTE.—The highest tide each day is underscored with a red line; the lowest tide each day is underscored with a blue line.

REMARKS.—Average daily rise and fall for the 31 days recorded, three feet two inches; highest tide recorded for the 31 days, four feet four inches, August 10; least rise of tide recorded for the 31 days, two feet, September 7; lowest low tide for the 31 days recorded, —0 feet eight inches, August 26 to 31; least fall of tide for the 31 days recorded, four inches, September 4, 5, and 7. These figures all refer to the tide gauge zero as it stood at the assumed mean low-water mark. The height of the gauge zero above the *average* mean low-water mark for the time recorded, as determined from this record, was two inches. The mean low-water mark for the time observed is 3.351 feet *below* the "bench mark U. S.," which is a hole drilled in the large rock at the end of the wall running into the water at the landing, with the letters "U. S." cut beside it.

C.

Record of the thermometer, the direction of the wind and weather, kept at Block island, during the survey for a breakwater at that point, 1867.

1867.	Thermometer.			Direction of wind.			Weather.		
Date.	7 a. m.	1 p. m.	6 p. m.	7 a. m.	1 p. m.	6 p. m.	7 a. m.	1 p. m.	6 p. m.
	°	°	°						
July 20	60	62	.....	.....	.....	.....	.....	.....	.....
July 21	58	63	60	.....	.....	.....	.....	.....	.....
July 22	65	70	.....	.....	.....	.....	.....	.....	.....
July 23	78	75	67	.....	.....	.....	.....	.....	.....
July 24*	74	74	67	.....	.....	.....	.....	.....	.....
July 25	67	75	68	.....	.....	.....	.....	.....	.....
July 26	63	73	68	NE.	NE.	NE.	Fog.	Fog.	Fog.
July 27	69	63	63	S. SE.	S. SE.	S. SE.	Fog.	Fog.	Fog.
July 28	68	73	69	S. SE.	S. SE.	S. SE.	Fog.	Fog.	Fog.
July 29	66	68	66	S. SE.	S. SE.	NW.	Rain.	Rain.	Clear.
July 30	64	69	63	SW.	SW.	SW.	Clear.	Clear.	Clear.
July 31	64	64	62	S. SE.	S. SE.	S. SE.	Fog.	Fog.	Fog.
August 1	63	65	62	S. SE.	S. SE.	S. SE.	Fog.	Fog.	Fog.
August 2†	67	66	64	SE.	E. SE.	NW.	Rain.	Rain.	Rain.
August 3	66	68	65	S. SW.	S. SW.	S. SW.	Thick.	Fog.	Fog.
August 4	68	67	64	Calm.	Calm.	Calm.	Cloudy.	Cloudy.	Cloudy.
August 5	78	74	79	SW.	SW.	SW.	Clear.	Clear.	Fog.
August 6	66	69	65	E.	E.	E. SE.	Cloudy.	Clear.	Fog.
August 7	66	66	66	SE.	SE.	SE.	Thick fog.	Thick fog.	Thick fog.
August 8	66	68	65	SE.	SE.	SE.	Thick fog.	Thick fog.	Thick fog.
August 9	76	68	66	SW.	SW.	SW.	Clear.	Clear.	Clear.
August 10	70	74	68	SE.	E.	SW.	Fog.	Overcast	Clear.
August 11‡	66	72	68	SW.	SW.	SW.	Clear.	Clear.	Clear.
August 12	68	70	70	SW.	SW.	SW.	Clear.	Clear.	Clear.
August 13	66	70	68	SW.	SW.	SW.	Fog.	Fog.	Fog.
August 14	68	74	71	SW.	SW.	SW.	Clear.	Clear.	Clear.
August 15	70	69	69	S.	S. SE.	S. SE.	Thick fog.	Thick fog.	Thick fog.
August 16	68	70	67	E. SE.	SW.	SW.	Rain.	Gale.	Clear.
August 17	76	73	68	SW.	S SW.	SW.	Rain.	Fog.	Fog.
August 18	78	73	68	W. SW.	W. SW.	W. SW.	Clear.	Clear.	Clear.
August 19	73	75	70	W. SW.	W. SW.	W. SW.	Clear.	Clear.	Clear.
August 20	76	76	70	NW.	SW.	Calm.	Clear.	Clear.	Clear.
August 21	74	77	70	NW.	SW.	Calm.	Clear.	Clear.	Clear.
August 22	67	68	67	SE.	SE.	SE.	Cloudy.	Rain.	Rain.
August 23	67	70	67	SE.	SE.	SE.	Rain.	Rain.	Rain.
August 24	64	72	68	NW.	SW.	SW.	Fog.	Clear.	Clear.
August 25	74	75	67	SW.	NW.	Calm.	Clear.	Clear.	Clear.
August 26	80	74	70	Calm.	SW.	Calm.	Clear.	Clear.	Clear.
August 27	72	74	70	Calm.	SW.	S.	Clear.	Clear.	Clear.
August 28	74	74	71	SE.	SE.	SE.	Clear.	Clear.	Clear.
August 29	71	72	70	S. SW.	S.	S.	Fog.	Showers.	Rain.
August 30	68	69	64	SW.	SW.	SW.	Clear.	Clear.	Clear.
August 31	64	64	64	SE.	SE.	SE.	Clear.	Clear.	Clear.
Sept. 1	62	65	62	NE.	SE.	SE.	Rain.	Rain.	Rain.
Sept. 2	64	67	65	NW.	SE.	SE.	Fog.	Fog.	Fog.
Sept. 3	65	69	64	SE.	SE.	NE.	Clear.	Clear.	Cloudy.
Sept. 4	66	70	66	SE.	SE.	SE.	Cloudy.	Cloudy.	Cloudy.
Sept. 5	70	70	65	SE.	SE.	SE.	Cloudy.	Cloudy.	Cloudy.

* 78° at 11 a. m.
† The heaviest gale for the time of year ever known.
‡ One hundred and forty-six vessels in sight at once at 11 a. m.

The thermometer used was hung upon a post of the piazza of the Spring House, and belonged to the proprietor, Mr. Alfred Card. Although it was at all times in the shade, it was undoubtedly affected in the morning, when the sun was bright, by the reflection from the water, and marked a higher temperature than actually existed where this was not felt. This effect, however, would cease after 10 o'clock a. m. The place selected for the themometer was the best, everything considered, that could be found.

By reference to the table it will be seen that during the time, part of July, the whole of August, and a part of September, the highest temperature indicated was 78°. The universal testimony of the people was to the effect that it was very unusual to have so many foggy and rainy

days as we had during the time at that season. The weather is usually clear, with very little fog after June, and thunder-showers very seldom occur on the island, though they are constantly seen passing either to the north or to the south of the island. In winter it is said that the temperature is several degrees higher than on the main land north of Block island.

GEORGE W. DRESSER,
Assistant Engineer in charge of Survey.

D.

Letter from the collector of customs at Newport, Rhode Island, in answer to inquiries regarding the fisheries at Block island.

CUSTOM-HOUSE, NEWPORT, RHODE ISLAND,
Collector's Office, December 27, 1867.

SIR: Your favor of yesterday is at hand, and contents noted. I have no knowledge of the amount of produce of the island, but I have written to Captain Ball for the same, and will inform you when received.

I find, by my notes upon the statistics of the fisheries of the island, that from 1789 to 1866 there were caught by the inhabitants of Block island 355,000 quintals of codfish. At an average price of $4 50 per quintal, this gives $1,595,500, or $22,500 per year; on which they never have received the fostering care of the government by way of bounty, which would have amounted, as near as I can make it, to $18,229. This has arisen from want of a harbor in which to lay their vessels, consequently could use nothing but *boats* for fishing.

Hoping this will give you the desired information upon this head, I am, very respectfully, your obedient servant,

S. W. MACY,
Collector, &c.

GEO. W. DRESSER, Esq.,
Major and Civil Engineer.

E.

The following is a copy of a letter and a statement furnished me by S. W. Macy, esq., collector of customs at Newport, Rhode Island, containing the information referred to and promised in the foregoing letter:

NEW SHOREHAM, BLOCK ISLAND,
January 8, 1868.

DEAR SIR: Yours of the 30th was received last Saturday, and I have taken pains and got the most reliable information that I could upon the statistics of our exports and imports in the last 10 years. Having been in the business of the island for about 14 years, I have a good opportunity to know about the actual amount of the most of our traffic. I inclose the statement which you ask for, and consider it a fair estimate, and hope you will be able to use it to good advantage.

I am, sir, very respectfully,

NICHOLAS BALL.

Captain S. W. MACY, *Collector, &c.*

The following is the statement, and although it is an estimate, I have no doubt that it is sufficiently accurate to show about what the yearly products are *over and above what is required for home consumption*, as I know Mr. Ball to be reliable.

F.

Statement of the average yearly shipments of products from Block island the last ten years, as estimatea by Nicholas Ball, esq., of New Shoreh Rhode Island.

20,000 bushels of oats.
3,000 bushels of corn.
10,000 bushels of onions.
5,000 bushels of potatoes.
15,000 bushels of oysters.
100 tons of poultry, (chickens, turkeys, geese, and ducks.
6 tons of wool.
6 tons of wool, manufactured into socks, &c.
25 tons of black sand.
2,000 tons of paving stones, (cobble stone.)
200 tons of fresh blue fish.
50 tons of fresh codfish.
20 tons of fresh eels.
250 head of cattle, horses, &c
1,000 head of sheep.
1,000 head of swine.
1,000 barrels of Irish moss.
350 barrels of fish oil.
40,000 dozen of eggs.
25,000 quintals of dried codfish.

Estimated imports to Block island—General merchandise to the v of $150,000 yearly.

G.

List of vessels wrecked on Block island, Rhode Island, from January 1, 1 to Januarg 1, 1868.

No.	Date.	Names and class of vessels.	Dam and l
1	February, 1854 ...	Rattlesnake, schooner	$
2	May, 1854	President, schooner	1
3	September 6, 1854.	Patriot, brig	1
4	September 6, 1854.	Trident, schooner	1
5	September 6, 1854.	Eben Herbert, schooner	
6	September 6, 1854.	Medora, schooner	
7	September 6, 1854.	Statesman, schooner	
8	September 6, 1854.	Isabella, schooner	
9	January 29, 1855.	Malunckus, brig	
10	May, 1855	Vermont, brig	
11	June, 1855	Crompton, schooner, coal	
12	October 31, 1855 ..	Warden, bark, ballast	
13	February 2, 1856 ..	Gem, bark, from Africa	3
14	February 2, 1856 ..	John S. Brooks, schooner, coal	
15	March, 1856	Lucullus, schooner, timber	
16	January, 1857	Rough and Ready, schooner, plaster	
17	February, 1857 ...	Denja, bark, West Indies	
18	October, 1857	Parodi, bark, coast of Africa	3
19	October, 1857.....	Kossuth, sloop, ballast	
20	November, 1857...	Monticello, brig, logwood	
21	November, 1857...	West Falmouth, schooner, iron	
22	March 21, 1858....	Palmetto, steamship, assorted	9
23	April 27, 1858.....	Walden, schooner, ballast	
24	May 12, 1858	Trade Wind, sloop, potatoes	
25	June 9, 1858.....	Lucy Ann, bark, West Indies	
26	December 9, 1858.	Welcome Return, schooner, pig iron	
27	May 21, 1859	Londonderry, schooner, plaster	
28	June 19, 1859.....	Temperance, sloop, iron	
29	September 25, 1859.	Lucy Emeline, sloop, ballast	
30	February 19, 1860.	Franklin Treat, schooner, corn	1

List of vessels wrecked on Block island, Rhode Island, &c.—Continued.

lo.	Date.	Names and class of vessels.	Damage and loss.
31	September 8, 1860.	W. H. Dennis, schooner, ballast	$900
32	October 18, 1860 ..	Almeda, schooner, ballast	5,500
33	November 14, 1860.	Hero, schooner, ballast	500
34	February 21, 1861.	Grecian, schooner, ballast	700
35	April 8, 1861.....	Boundary, schooner, lumber	900
36	July 11, 1861	Randal S. Smith, schooner, coal	600
37	September 28, 1861.	M. H. Sheldon, schooner, coal	8,250
38	November 30, 1861.	Norman, schooner, coal	200
39	July, 1862.....	Manelett, (English,) schooner, coal	6,500
40	October 10, 1864 ..	Henry, (English,) brig, assorted	15,000
41	March, 1865	Angler, (English,) schooner, coffee and logwood.	3,000
42	December 21, 1865.	Mary E. Thompson, brig, hides, wool, and cotton.	3,000
43	December 21, 1865.	Ellen Forrest, schooner	3,000
44	January 7, 1866 ...	Augusta, schooner, lime	5,000
45	November 30, 1866.	Agnes, schooner,	12,000
46	July 29, 1867	Union, schooner, corn	2,000
47	July 29, 1867	Mary Barden, (English,) schooner, ballast	4,500
48	September 30, 1867.	Jennie, sloop, stone	500
		Total damage and loss	378,050

H.

CUSTOM-HOUSE, NEWPORT, RHODE ISLAND,
Collector's Office, January 8, 1868.

SIR: Your letter of to-day is at hand and contents noted. The numr of this district is 29.

Revenue collected from imports from June, 1866, to June, 1867, 1,884 05.

There was a great falling off in the imports at this port from 1866 to 67, caused by the southern ports being opened to commerce again. ıese ports being now supplied, the trade is tending northward again.

I am, very respectfully, your obedient servant,

S. W. MACY,
Collector, &c.

D. C. HOUSTON,
Major and Brevet Colonel U. S. A., Newport, R. I.

APPENDIX Q.

NEW BEDFORD, MASSACHUSETTS,
September 17, 1868.

GENERAL: I have the honor to submit the following report of operaıns on Plymouth beach, Massachusetts, during the year ending June , 1868.

No additional work has been built during the year. A small balance available funds has been expended in repairing the breakwater built e previous year.

nount available June 30, 1867 ..... $111 11
ɪpended during the year 111 11

of coasting vessels visit the port, having no occasion to register i district.

The amounts expended during last fiscal year and required for ending June 30, 1870, are given above.

I am, general, very respectfully, your obedient servant,

JARED A. SMITH,

Brevet Major U. S. A., Corps of Engine

Brevet Major General A. A. HUMPHREYS,

Chief of Engineers U. S. A., Washington, D. C.

Q 1.

TAUNTON RIVER.

NEW BEDFORD, MASS., *March* 18, 18

GENERAL: On the 24th ultimo I received from headquarters of engineers a communication directing me to examine plans for a posed improvement of Taunton river, Massachusetts, and report the Charts giving the outlines and soundings of the river were also rece

In accordance with the above, I have the honor to submit th lowing report and estimate:

Owing to the inclemency of the weather, together with the river filled with ice unusually late in the season, I have been unable to a personal examination of the channel. The report of Captain Du as appended to the memorial of citizens of Taunton, explains the m so fully that a further examination would seem unnecessary; a would respectfully refer to it for matters which I may seem to overlooked. At the time of the above report, in 1853, the town of T ton numbered about 12,000 inhabitants. In 1868 it numbers 2(and, so far as I can ascertain, its business, especially that portion de ent upon the navigation of the river, has increased in a greater portion than its population

passing up the river would undoubtedly be greatly increased were the means for its transportation improved.

Previous to the survey by Lieutenant Rosecrans the channel of the river was considerably improved, through private subscription, by the removal of some of the principal obstacles, as boulders, &c.; and it has been observed that since these obstructions were removed high water has averaged several inches (about eight) above its previous level. It has also been observed that where the bars were thus broken the tendency of the water has been to wear them away, while the character of the valley drained is such that no new deposits are formed.

No further improvements of the channel have been made, but the navigation has been somewhat improved by the removal of a bridge, shown on the chart as Berkley's, and the construction of a draw in the bridge at Weir village. No changes worthy of note have taken place in the river's bed since the survey by Lieutenant Rosecrans in 1852.

It will be seen, therefore, by reference to the chart, that with high water at the average level, a vessel cannot pass over the bars with more than five feet draught of water. Were these bars removed I think it would be found that the depth of water, under the above circumstances, would be increased somewhat more than the depth excavated, owing to the increased section giving less obstruction to the tidal wave and permitting a larger quantity of water to flow up the stream in a given time. Aside from this the bars, being loosened by dredging, would undoubtedly be worn somewhat deeper by the action of the current.

I find the places requiring the channel to be deepened are over the shoals numbered respectively 1, 2, 3, and 4; also near Cobb's wharf, at Dighton; a second near the former position of Berkley's bridge, and a third near Weir village and above No. 1.

It is not expected that the removal of any portion of these shoals will benefit the navigation at low water. There can at present be no passage of the river, under these circumstances. High water would, however, be sufficient for all purposes, as a single flood tide would permit vessels to be towed from Dighton to Taunton and return with nearly the maximum depth of water.

As nearly as I can ascertain from the charts, the amounts required to be excavated, to carry out the plan heretofore proposed, *i. e.*, to make a channel 60 feet wide, and to a depth of four feet below the present low-water mark, are as follows:

	Length, yards.	Contents, cubic yards.
No. 1	454	4,000
No. 2	762	6,700
No. 3	399	3,600
No. 4	333	3,000
At Dighton	120	800
Berkley's bridge	100	350
Weir village	350	2,000
Total	2,518	20,450

The nature of these shoals has already been explained in Captain Dutton's report. The dredges at present used for removing submerged deposits would probably be sufficient for these excavations. The boulders would require the use of scows and drilling for their removal.

Brevet Major General A. A. HUMPHREYS,
Chief of Engineers U. S. Army,
Headquarters Corps of Engineers, Washington, D. C.

APPENDIX R.

BOSTON, MASS., *September* 5, 1

GENERAL: I have the honor to make the following report of prog the works of harbor improvement under my charge during the fisc ending the 30th of June, 1868:

PRESERVATION AND IMPROVEMENT OF BOSTON HARBOR.

As soon as the preliminary surveys were completed, proposal invited for dredging the southwest point of Lovell's island, for ing the channel across the upper middle bar, and for blasting and ing the rocks in the narrows between the light on the west extrer Great Brewster spit and Fort Warren.

The contract for dredging the southwest point of Lovell's islar awarded to Mr. Albert Boschke, the lowest bidder. Under his co the work has been prosecuted with vigor, and 92,899 cubic ya dredged material removed, widening the channel at that point feet at the low-water line, and to an average depth over the di area of 13 feet at mean low water. A larger and more powerful dr machine is now being built by Mr. Boschke, intended to carry the dep this dredged area to 23 feet at mean low water, the depth requi contract and by the requirements of navigation.

It is also proposed to dredge off a portion of the extreme south of Lovell's island, and the edge of the shoal on the east side of G island, directly opposite Lovell's island.

Total amount expended during the fiscal year ending June 30 $46,258 02; probable amount to be expended during the fiscal year e

refused to comply with the terms of his contract in prosecuting it in any manner, or in paying the forfeited amount of his sureties. The contract was then given to Wm. W. Wright, of Geneva, New York, the other bidder, who gave the requisite securities for the performance of the work. As, however, he had previously been notified that the contract had been awarded to Mr. Wooley, he had in the meantime disposed of the dredging machine with which he proposed to do the work, and was unable afterwards to procure a dredging machine of sufficient power in time, and he transferred his contract to Mr. Albert Boschke, of this city. The work was not commenced on the 30th of June, 1868.

Amount expended during the fiscal year ending June 30, 1868, $3,454 11; probable amount to be expended during the fiscal year ending June 30, 1869, $35,545 89; amount required to complete the dredging at this point to a depth of 23 feet at mean low water, and a width of 1,000 feet, as estimated for by the board of harbor commissioners, $118,085.

Blasting and removing Tower and Corwin Rocks.—This work has been successfully carried on under the direction of Mr. George W. Townsend, contractor, and has resulted in the entire removal of Tower Rock to a depth of 23 feet at mean low water, and the entire removal of Corwin Rock and the adjacent ledge lying between Corwin Rock and Fort Warren to a general depth of 22 feet at mean low water, and over the larger portion of its surface to 23 feet at mean low water. Six hundred and fifty tons of rocks have been blasted from these rocks, hoisted up, and deposited on shore. Many tons of small fragments that were thrown into deep water by the explosion of the blasts were suffered to remain on the bottom, where they in no way interfered with navigation.

The amount available will, it is expected, nearly complete the entire removal of these rocks, heretofore so dangerous to navigation. Amount expended during the fiscal year ending June 30, 1868, $20,842 25; probable amount to be expended during the fiscal year ending June 30, 1869, $9,157 75.

SEA-WALL AT POINT ALLERTON.

As there were no funds available for the purchase of the site necessary for the construction of this wall, application was made by the engineer in charge to the legislature of the Commonwealth of Massachusetts for the appropriation of the sum necessary to purchase the strip of ground near high water, upon which to build the wall, together with the shoals in front, and the necessary slope in rear, to be presented in fee simple to the United States. The necessary sum, $175, was appropriated at the last session and is now available. As soon as the necessary examination of title can be made, the purchase and transfer to the United States will be completed, after which the work may be commenced, as agreements have already been made for the rent of the portion of the adjoining land necessary to be used in the construction of the wall. Amount expended during the fiscal year ending June 30, 1868, $4,889 52; probable amount to be expended during the fiscal year ending June 30, 1869, $45,110 48; amount required to complete the work, $20,991 87.

SEA-WALL FOR THE PRESERVATION OF GALLOP'S ISLAND.

Upon application of the engineer in charge the city of Boston, which owns this island, presented to the United States the strip of ground upon which to build this wall, with the shoals in front and slopes in

SEA-WALL FOR THE PRESERVATION OF THE NORTH HEAD OF I ISLAND.

The negotiations for the purchase of the north head of this is with the low land adjacent, for military purposes, having failed to o a favorable result, the officer having it in charge, Brevet Major Ge H. W. Benham, was ordered to co-operate with Brevet Major Ge J. G. Foster in the effort to obtain, from the legislature of the Com wealth, the passage of a law providing for the acquisition of the to the necessary land by the United States.

Application was accordingly made, and was successful in obta the passage of a law providing for the determination of the price paid by the United States, by means of the jury of the superior of the county, and the vesting of the titles in fee-simple in the U States, upon the deposit of the sum so determined in the hands o judge of the court. Application will be made to the court at its session, and as soon as the titles are thus secured the sea-wall m commenced.

Experiments upon various kinds of materials for pavements in re the coping of sea-walls were carried on during the winter, and rep upon in a special report. Amount expended during the fiscal year ing June 30, 1868, $7,674 54; probable amount to be expended d the fiscal year ending June 30, 1869, $67,325 46; amount required appropriated for the fiscal year ending June 30, 1870, to complet work, $75,000.

PRESERVATION OF PROVINCETOWN HARBOR, CAPE COD, MASSA SETTS.

Amount expended from appropriation for preservation of Prov town harbor for the fiscal year ending June 30, 1868, $6,542 42; able amount to be expended during the fiscal year ending June 30, $36,751 26; amount required to be appropriated for the fiscal year

of Boston harbor is substantially that of the harbor commissioners of the Commonwealth of Massachusetts, which has met the general approval of the Chief of Engineers.

The items of this plan are as follows, viz:

For dredging a channel across the upper middle bar 1,000 feet in width, and to a depth of 23 feet at mean low water, at a total estimated cost of	$157,085 00
For dredging off the southwest point of Lovell's island and the extremity of Great Brewster spit, so as to widen the channel to 685 feet at the 18-feet curve of the depth, and to carry the dredging to the depth of 23 feet at mean low water, at a total estimated cost of	188,805 00
For the removal, by blasting, of Tower Rock and Corwin Rock to a depth of 23 feet at mean low water, at an estimated cost of	20,000 00
For the construction of a sea-wall around the north head of Long island, at an estimated cost of	150,000 00
For the construction of a sea-wall around the extremity of Point Allerton, at an estimated cost of	70,991 87
For the construction of a sea-wall around the north end of Gallop's island, at an estimated cost of	103,585 63
Total for the preservation and improvement of Boston harbor	690,467 50

The result of resurvey and actual work of removal have shown that the cost of removing Tower and Corwin Rocks, by blasting, to the required depth will exceed the sum of $30,000. Also that the western extremity of the Great Brewster spit has ceased to extend itself into the channel, and that the removal of Tower and Corwin Rocks will render unnecessary the dredging off this spit. Also, that the cut at the southwest point of Lovell's island should be extended, at the depth of 23 feet, entirely along that side of the island parallel to the axis of the channel, and that a similar and parallel cut should be made, on the opposite side of the channel, from the shoal on the northeast side of Gallop's island.

2d. The amounts that are required for the entire and permanent completion of each work of preservation and improvement under my charge are given in the previous paragraph, No. 1, with the exception of the removal of Tower and Corwin Rocks, which will cost $35,000.

3d. The amount that can profitably be expended upon each work during the next fiscal year is as follows, viz:

IN BOSTON HARBOR.

For the sea-wall at the north head of Long island	$75,000
For the sea-wall at Gallop's island	54,000
For the sea-wall at Point Allerton	21,000
For dredging the southwest point and southwest side of Lovell's island and the northeast side of Gallop's island	99,805
For dredging the upper middle bar	118,085
For blasting and removing Corwin Rock	15,000
Total	382,890

Cod, are located, those at Long Point near Long Point light-hou
those at Beach Point and in the Salt Meadows are about equally
from the latter light-house and Cape Cod light-house.

6th. The amount of revenue collected at the port of Boston
the fiscal year ending June 30, 1868, as communicated to me
collector of the port, Judge Thomas Russell, is $15,974,581 3
amount collected at the port of Provincetown, as communicate
by the officer of customs, Mr. Isaiah Gifford, of Provincet
$5,324 61.

7th. The collector of the port of Boston informs me that the
of commerce and navigation that will be benefited by the w
improvement in this harbor will be as follows, viz:

Whole number of vessels that enter and leave by the channel
the Narrows annually, 24,000. Amount of tonnage during th
year ending June 30, 1868, was as follows, viz:

Tonnage entered from foreign ports	
Tonnage entered from domestic ports	
Tonnage cleared for foreign ports	
Tonnage cleared for domestic ports	1,
Total tonnage entered and cleared at Boston	3,

The amount of commerce to be benefited by the proposed i
ment it is difficult to estimate, as no approximation can be mad
amount of coasting trade. The imports and exports, howe
accessible, and amounted during the last fiscal year to the follo

Total imports	37,
Total exports	17,
Aggregate amount of foreign commerce	54,

No report has been received yet from the officer of customs at I

Abstracts of proposals received for improving harbor at Boston, Massachusetts.

Nature of work.	Name of bidder.	Amount bid for.	Price.
Dredging off the southwest point of Lovell's island.	Albert Boschke, Boston, Massachusetts.	140,000 cubic yards (more or less.)	50 cents per cubic yard.
	W. W. Wright, Geneva, New York.	140,000 cubic yards (more or less.)	$1 25 per cubic yard.
Dredging a channel across the upper middle bar.	Charles Wooley, Boston, Massachusetts.	40,000 cubic yards (more or less.)	75 cents per cubic yard.
	W. W. Wright, Geneva, New York.	40,000 cubic yards (more or less.)	75 cents per cubic yard.
Blasting and removing Corwin and Tower Rocks, 1st series.	George Clapp and George W. Townsend, of Boston, Massachusetts.	Whole work.....	$44,500.
Ditto, 2d series.....	George W. Townsend....	Day's work.....	$90 per working day.
Ditto, 3d series.....	George W. Townsend....	Day's work.....	$100 per working day of 9 hours.
Ditto, 4th series.....	George W. Townsend....	Day's work.....	$85 per working day.

I inclose abstracts of bids received for sea-wall on Gallop's island, marked A, abstract of contracts, marked B, and abstract of prices, of material and labor, marked C.

R 1.

BOSTON, MASS., *December* 31, 1867.

GENERAL: I have the honor to make the following report of the operation of removing Tower Rock in the harbor of Boston:

This rock was situated in the Narrows between the extremity of the Great Brewster spit and Fort Warren, about 100 yards southwest from the Spit light, commonly called the "Bug light." It thus stood directly upon the edge of the main ship channel, as will be seen by reference to the accompanying sketch A; and having only 18½ feet of water upon it at mean low water, constituted, with Corwin Rock, situated 100 yards from the former and almost in the middle of the channel, with 16 feet at low water, dangerous obstacles to navigation.

The amount available for the removal of these two rocks to a depth of 23 feet at mean low water was $20,000.

Proposals were advertised for on June 18, 1867, which being opened on the 1st of July contained only one bid, and that for $44,000. This, exceeding the sum available for the work, was rejected.

On July 10 a contract was made with Mr. George W. Townsend to do the work for $90 per day, he to furnish a vessel, machinery, two submarine divers, and all materials and necessary appliances.

Work was commenced July 29, 1867, on Tower Rock, which, being the smaller and more accessible, it was decided to remove first. The operation was conducted by first mooring the working vessel, a sloop of about 60 tons, directly over the rock by means of four mooring buoys placed at equal distances apart around the rock and about 20 yards from it. Another buoy was placed directly upon the rock to mark its position distinctly, in case the sloop should be forced by accident or stress of weather to leave her moorings and seek a harbor.

A careful examination of the rock by the divers disclosed it to be a firm, compact, and very hard slate about 50 feet long by 26 wide. (See sketch A.) Its surface, being quite smooth and rounded, resisted all trials to break it by the explosion of large charges of powder upon its

face and at its sides. The drilling machine of Mr. Townsend was therefore placed upon the rock and firmly fastened to it by guys, and the process of drilling for blasting commenced.

As this machine is new, I will give a brief description of it and its working. It consists (sketch B and photograph) of three general parts, the drill, the frame in which the drill works, and the appliances for operating it. The drill (*a b c*) consists of an iron shaft (*a b*) 16 feet and nine inches long and two inches in diameter, to which is attached at its lower end, by a socket and key, the drill-head or cutter, (*b c.*) This cutter is about 20 inches in length and 3½ inches across the cutting edge. The shaft and cutter weigh about 200 pounds. The cutting edge of the cutter is made in a peculiar form, which is found to stand better than any other, being similar to the letter S. (See *c*, sketch B.)

The drill frame consists of two boiler-iron plates (*f g* and *e h*) connected by uprights, (*j j j*,) and supported by legs (*d i*) adjustable to different lengths to suit the uneven surfaces of the rocks. The frame is kept firmly in position by guys (*l l l*) attached to the upper, and when necessary, to the lower plate. These guys are then made fast to bolts driven into small holes drilled in the surface of the rock by the diver with a hand drill.

The apparatus for operating the drill consists of a clutch (*m n*) having an oblique slot, (*p*,) the sharp opposite edges of which catch the drill and raise it by their friction. The forked end of the clutch (*q u*) slides upon an inclined rod (*r*) so as to give the necessary turn to the drill in rising. A pin (S) fixed at the proper height disengages the clutch and allows the drill to fall straight, cutting the rock by the force due to its gravity. The height of fall is made adjustable by the position of the pin (S) so as to suit the texture and hardness of different rocks, being usually made as great as the edge of the cutter will stand. Upon Tower Rock the fall was six inches. The clutch is operated by a chain (*o*) which passes through a hole (*t*) in the upper plate, and is attached to a single block, (*u*,) through which passes a rope leading to the vessel; one end of the rope being attached to the adjustable crank-pin (*v*) of a small steam-engine, and the other to a cleat (*w*) on the rail of the vessel, to allow the line to be taken in and let out so as to accommodate to the fall and rise of the tide. To put the drill in operation, motion is given to the steam-engine and communicated to the disk, (*v x.*) As the crank-pin rises from its lowest to its highest point it draws up the drill line, which raises the block and the drill chain half as far; this raises the clutch, which catches the drill between its sharp edges and raises it, turning as it raises until the fork of the clutch strikes against the pin (S) upon the inclined slide, when the drill instantly becomes disengaged and falls. The crank-pin, passing from the highest to the lowest point, lowers the drill-rope block and chain, and thus permits the clutch, which is weighted at one end, (*m*,) to fall to its lowest point, where it is held by an adjustable pin (*y*) ready to catch the drill again at the instant the clutch commences to be raised. The operation is repeated and the drilling thus proceeds.

The fragments and powdered stone are usually removed with a long spoon, the drill being raised clear of the hole for the purpose by means of the hoisting apparatus of the vessel. This "spooning out" and all other operations of the drill are attended to by the diver, with whom constant communication is maintained through a signal line.

Generally a rod (*z*) and a wooden pole (*y'*) of sufficient length to reach above the water are fitted into the upper end of the drill to afford a constant index to its motion.

Sometimes the air hose of the force-pump is introduced, and air forced

to the bottom of the hole, which is by this means cleared more thoroughly and quickly than by the most careful spooning out.

It is proposed to have a small hole along the axis of the drill, through which a stream of water is to be forced to drive out the cuttings by the mechanical force of the water, and thus keep the drill constantly clear.

The swell of the sea is provided for by the form of the slot in the clutch, which is made long enough to afford the requisite play; besides this, the vessel need not lie directly over the drill, but at any convenient distance, since the drill line can have a considerable vertical angle above the top plate of the frame.

The adjustable legs and guys also allow the frame to be set, and the drill to be worked at a small angle from the vertical, and thus drill into the sides of the rocks at a corresponding inclination.

Operated in the usual way at the ordinary rate, the drill made from 40 to 60 blows in a minute, and drills a hole three and a half inches in diameter to an average depth of five feet in a day.

At first great difficulty was experienced in giving a good temper and form to the cutting edge of the drill-head. In consequence the first five holes were only sunk to the depth of three feet, and the blasts made in them proved of little effect.

As the cutter was improved the holes were sunk deeper, until finally the S form of the edge being hit upon enabled us to drill eight feet in depth. The blasts in these holes were very effective, and three such enabled us to entirely break up the rock.

The powder used at first was Dupont's best sporting powder, of which the charge varied from 6 to 20 pounds. The powder did not, however, seem to be strong enough to throw out the large masses of rock in which the drills were sunk. Often the only effect, even in the eight feet holes, was to blast out the tamping like the shot from a cannon, and with little more injury to the holes. Twenty kegs of powder of 25 pounds each were used in this way. Finally, a trial was made of Dr. Ehrhardt's "patent blasting powder," of the composition of 50 parts of chloride of potash to 50 parts of cutch, which did not effect much more than powder; but on making it stronger by increasing the proportion of chloride to 80 per cent. of chloride of potash to 20 of gambier, the effect was greatly increased, and seemed to be double that of powder. The use of about 80 pounds of this powder completed the entire disruption of the rock.

Upon one or two occasions the blasts left narrow seams in the rock, in which a small quantity of a very strong compound could have been used with great advantage, and efforts were made to obtain nitro-glycerine for that purpose, but none could be procured in time for use on that rock.

The cylinders to contain the charges used in blasting this rock were at first made of tin, of which six dozen were used; after which those made of India-rubber were used, and found to be better and more easily introduced into the holes.

About 150 cartridges of this material, of the ordinary size, were used, beside two dozen large bags for seam blasting. The charges were ignited by an electrical fuse (see sketch C) placed inside the cartridge, and attached usually to a double wire in a single gutta-percha covering, around which the mouth of the cartridge was hermetically closed. This double wire extended to a small friction battery on the deck of the vessel. (See sketch C.)

To discharge a blast the drilling machine was first hoisted on board; then the cartridge was placed in the hole by the diver, who introduced above it the tamping, and then came up. The vessel being then hauled

at low and 33 feet at high water, the sand became so affected
buoyancy of the water as to be deprived of the compactness ne
to produce effect. In fact, the effect with sand, or with no tam
all, seemed the same at that depth. Metal tamping arrangemen
then used. Of these the Lewis form (sketch C) was always eff
but had the disadvantage of being introduced with difficulty.
metal cylinder (sketch C was then tried with success, as it co
lowered directly upon the charge, and at the explosion seemed to
like the cup of the minié ball and to adhere to the sides of th
by friction. Generally, however, the best results were obtained
exploding in the hole successive charges, without tamping, until
were started in various directions; then to use a heavy charge
good tamping like the gun-metal cylinder, so as to hoist out
masses of rock that had been thus disconnected by the seams.

The quantity of rock removed from Tower Rock was abo
tons, of which 80 tons, being in large masses from one to eight
weight, were hoisted up and deposited upon the beach. As the
of the channel was only a few feet below the rock when finishe
the smaller pieces that had been blown off were suffered to rem
the bottom around the rock.

The work on this rock was completed upon the 26th September,
occupied nearly two months.

The total cost was $5,194 71, or $34 63 per ton; the total res
removal of this rock from a depth of 18½ feet to over 23 feet, a
low water.

I have the honor to be, general, your obedient servant,

J. G. FOSTER,

Brevet Major General U. S. A., Lieut. Col. Engi

CHIEF OF ENGINEERS,

Headquarters Corps of Engineers, Washington, D. C.

20,000 bushels clear pit sand.
4,000 barrels best hydraulic cement.
4,000 cubic yards broken stone, for concrete.
1,000 running feet granite coping; course 27 inches high.
1,000 running feet granite facing, 10 feet high.
1,000 tons irregular granite, for paving.

The *workmanship* is to be understood as to include all expenses whatever incident to building the wall from the above-named materials, and proposals therefor will express a price for each of the following-named items, viz:

1. For excavation of foundations, per cubic yard.
2. For making and placing concrete, per cubic yard.
3. For setting the header and stretcher courses of granite facing, per superficial foot of face.
4. For setting the coping course per foot, run of the wall.
5. For digging, removing, and depositing earth for back slope, and other excavations not of foundation, per cubic yard.
6. For laying the paving and preparing the surface for its reception, per square yard.

For work not included in the above items, per day's work, as follows:

7. Masons or stone cutters, per day.
8. Good laborers, per day.
9. Yoke of oxen, with cart or truck, and driver, per day.
10. A good horse, harness, cart and driver, per day.
11. For materials to be purchased, per cent. advance on actual cost.

The above rates per day will be understood to cover and include a general and faithful supervision. No bid for workmanship will be considered, unless all the above eleven items of price shall be distinctly set forth.

Separate bids may be entertained for the supply of the separate classes of material, but the United States shall not be bound to the acceptance of any bid, whether for material or workmanship, unless the engineer officer in charge shall be satisfied that the same is for the interest of the United States. Preference will be given to those proposals which cover most items. Plans and drawings showing the site and character of the work, and the full forms of contract and specifications required to be signed by the contracting parties, together with blank forms of proposal and guaranty, upon which the bids to insure consideration are required to be made out, will be open to inspection in this office from this date till the close of the bidding at 3 p. m. of the 15th instant.

J. G. FOSTER,
Brevet Major General U. S. A., Lieutenant Colonel Engineers.

Abstract of bids for construction of a sea-wall at Gallop's island, Boston harbor.

Bidders' names.	Clear pit sand, for 20,000 bushels, per bushel.		Best hydraulic cement, for 4,000 barrels, per barrel.		Broken stone for concrete, for 4,000 cubic yards, per cubic yard.		Granite coping course, for 1,000 running feet, per running foot.		Granite facing, for 1,000 running feet, per running foot.		Irregular granite for paving, for 1,000 tons, per ton.		Excavation for foundations, for 2,000 cubic yards, per cubic yard.		Making and placing concrete, for 3,000 cubic yards, per cubic yard.	
	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.
1. James Andrews, Biddeford, Maine	.....	.....	.....	.....	.....	.....	$7 10	$7,100	$19 25	$19,250	$2 50	$2,500	$0 50	$1,000	$0 60	$1,800
2. F. W. Hoxie & Co., Boston, Mass., agents of Newark Lime and Cement Manufacturing Co.	$0 15	$3,000	$2 25	$9,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3. Franklin Mead, Acton, Middlesex county, Mass.	.....	.....	.....	.....	$2 44	$9,760	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4. George H. Gordon, Boston, Mass.	12	2,400	2 75	11,000	6 00	24,000	10 00	10,000	20 00	20,000	4 00	4,000	1 00	2,000	2 75	8,250
5. *Wm. H. Williams, Little Falls, Herkimer co., N.Y.	10	2,000	2 50	10,000	5 00	20,000	12 37½	12,375	24 00	24,000	2 00	2,000	75	1,500	3 50	10,500
6. Frank Blaisdell & Oliver Trefethen, Boston, Mass.	.....	.....	.....	.....	3 00	12,000	11 10	11,100	21 99	21,990	2 50	2,500	1 00	2,000	2 50	7,500
7. Joseph W. Coburne, Boston, Mass.	19	3,800	2 25	9,000	5 20	20,800	12 80	12,800	22 00	22,000	3 25	3,250	40	800	2 80	8,400
8. Joseph Westcott & Son, Portland, Maine	12	2,400	2 25	9,000	5 00	20,000	12 00	12,000	20 00	20,000	3 00	3,000	1 25	2,500	4 00	12,000

* This bid was not made out upon the printed form required, and was without signatures of guarantors, as required by law.

Bidders' names.	Setting headers and feet, per superfi		Setting coping co 1,000 running		Excavating and en back slope, to cubic yards, p yard.		Laying pavement, square yards, p yard.		Masons or stonecu day.	Good laborers, per	Yoke of oxen, wit truck, and driver,	Horse, with cart a per day.	Per cent. on actua materials furni	Aggregate of bid.	Deduct bid as to ment, and broke	Aggregate of bid, for sand, cem broken stone.
	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Price.	Price.	Price.		Amount.	Amount.	Amount.
1. James Andrews, Biddeford, Maine	$0 38	$3,200	$1 40	$1,400	$0 25	$2,500	$1 75	$1,750	$3 50	$2 25	$6 00	$1 50	5	$40,500	.....	$40,500
2. F. W. Hoxie & Co., Boston, Mass., agents of Newark Lime and Cement Manufacturing Co.														12,000	.....	
3. Franklin Mead, Acton, Middlesex county, Mass.														9,760	.....	
4. Geo. H. Gordon, Boston, Mass	50	5,000	2 00	2,000	75	7,500	1 00	1,000	5 00	2 50	6 00	5 00	5	97,150	37,400	59,750
5. *Wm. H. Williams, Little Falls, Herkimer co., N. Y.	50	5,000	50	500	50	5,000	50	500	5 00	2 00	5 00	3 50	5	93,375	32,000	61,375
6. Frank Bladell & Oliver Trefethen, Boston, Mass	31	3,100	1 37½	1,375	1 00	10,000	2 50	2,500	5 00	2 25	5 00	5 00	10	74,665	12,000	62,665
7. Joseph W. Coburne, Boston, Mass	53½	5,250	1 68	1,680	68	6,800	2 80	2,800	5 35	2 50	6 00	4 50	5	97,380	33,600	63,780
8. Joseph Westcoat & Son, Portland, Maine	63	6,300	3 00	3,000	1 00	10,000	3 50	3,500	5 00	2 50	6 00	5 50	10	103,700	31,400	72,300

* This bid was not made out upon the printed form required, and was without signatures of guarantors, as required by law.

R 3.

Abstract of contracts made for the preservation and improvement of Boston harbor.

Names of contractors.	Nature of work.	Quantity, materials, &c.	Price.
Albert Boschké, Boston	Dredging off the southwest point of Lovell's island.	140,000 cubic yards, more or less.	50 cts. per cu. y'd
Chas. Woolley, Boston, Mass.	Dredging a channel across the upper middle bar.	40,000 cubic yards, more or less.	75 cts. per cu. y'd
Wm. W. Wright, Geneva, N. Y.	Do	40,000 cubic yards, more or less.	75 cts. per cu. y'd
Geo. W. Townsend, Boston, Mass.	Removal of Tower and Corwin Rocks.	Day's work	$90 per workin day.
Do	do	Day's work	$100 per workin day of 9 hours.
Do	do	Day's work	$85 per workin day.
T. W. Hoxie & Co., Boston, Mass.	Sea-wall on Gallop's island.	Cement	$2 25 per barrel.
	do	Sand	12 cts. per bushel.
Franklin Mead, Boston, Mass.	do	Broken stone	$2 44 per cu. y'd.
James Andrews, Biddeford, Maine.	do	Granite coping course	$7 10 per running foot.
Do	do	Granite facing	$19 25 per running foot.
Do	do	Granite for paving, for 1,000 tons.	$2 50 per ton.
Do	do	Excavation for foundation, 2,000 cubic yards.	50 cts. per cu. y'd.
Do	do	Making and placing concrete, 3,000 cubic yards.	$2 60 per cu. y'd.
Do	do	Setting headers and stretchers, 10,000 superficial feet.	32 cts. per superficial foot.
Do	do	Setting coping course, 1,000 running feet.	$1 40 per running foot.
Do	do	Excavating and embanking back slope, 10,000 cubic yards.	25 cts. per cu. y'd.
Do	do	Laying pavement, 1,000 sq. yards.	$1 75 per sq. y'd.
Do	do	Masons or stonecutters	$3 50 per day.
Do	do	Good laborers	$2 25 per day.
Do	do	Yoke of oxen	$6 00 per day.
Do	do	Cart or truck, and driver	
Do	do	Horse, with cart and driver, per day.	$4 50 per day.
Do	do	Per cent. on actual cost of materials furnished.	5 per cent.

J. G. FOSTER,
Bvt. Maj. Gen. U. S. A., Lieut. Col. Engineers.

K 4.

Abstract of contracts for each class of materials, and labor for each work.

Name of contractor.	Name of work.	LABOR.													MATERIAL.						
		Dredging, per cubic yard.	All labor, machinery, and materials, per day.	All labor, machinery, &c., suitable for submarine operations, except powder, cartridges, &c., per day.	Excavation for foundation, per yard.	Making and placing concrete, per yard.	Setting header and stretcher courses, per superficial foot.	Setting coping course, per running foot.	Excavating and embanking back slope, per cubic yard.	Laying pavement, per square yard.	Masons or stonecutters, per day.	Good laborers, per day.	Yoke of oxen, with cart or truck and driver, per day.	Horse, with cart and driver, per day.	Advance on actual cost of materials furnished, per cent.	Granite coping, per running foot.	Granite facing, per running foot.	Granite paving, per ton.	Cement, per barrel.	Broken stone, per cubic yard.	Clean pit sand.
Albert Boschké, Boston, Mass.	Dredging SW. point of Lovell's island.	$0 50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Chas. Woolley, Boston, Mass.	Dredging upper middle bar.	75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
W. W. Wright, Geneva, N. Y.	.... do.....	75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Geo. W. Townsend, Boston, Mass.	Removing Tower and Corwin Rocks.	.....	$90 00	$100 00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...
Geo. W. Townsend, Boston, Mass.	.... do.....	.....	.....	85 00	.....	.....	.....	.....	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
James Andrews, Biddeford, Maine.	Sea-wall on Gallop's island.	.....	.....	.....	$0 50	$2 60	$0 32	$1 40	$0 25	$1 75	$3 50	$2 25	$6 00	$4 50	$5 00	$7 10	$19 25	$2 50	.....	.....	.....
T. W. Hoxie & Co., Boston, Mass.	.... do.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	$2 25	.....	$0 12
T. Mead, Boston, Mass ..	.... do.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	$2 44	.....

J. G. FOSTER.
Bvt. Maj. Gen. U. S. A., Lieut. Col. Engineers.

R 5.

Statement of cash received and expended on account of appropriation for preservation and improvement of Boston harbor during the fiscal year ending June 30, 1868.

Cash on hand June 30, 1867		$10,000 00
Received during the year from treasury of U. S		101,000 00
Total to be accounted for		111,000 00
Expended during the year	$88,765 60	
Deposited to credit of Treasurer of U. S., Dec. 11, 1867	12,000 00	
Total accounted for		100,765 60
Balance remaining on hand July 1, 1868		10,234 40
Amount of appropriation available June 30, 1868		211,234 40
Amount required to be appropriated for the fiscal year ending June 30, 1870		382,890 00

J. G. FOSTER,
Bvt. Maj. Gen. U. S. A., Lt. Col. Engineers.

R 6.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., June 30, 1868.

GENERAL: In answer to the communication of the Committee on Commerce of the Senate, asking the views of the Secretary of War as to the propriety of the legislation proposed in an inclosed bill (S. 566) authorizing the construction of a bridge from Boston to East Boston, referred to this office for report, I beg leave to state that Lieutenant Colonel and Brevet Major General J. G. Foster, corps of engineers, in charge of works for the preservation and improvement of Boston harbor, has been directed to make inquiries into and report upon the injury to navigation and to the interests of the United States which would probably result from the construction of a bridge in this locality. His report, which is early expected, will be transmitted as soon as received.

So far as at present informed, it is clear that there are serious objections to authorizing the construction of such a bridge:

1. It will restrict and embarrass the access to the navy yard at Charlestown.

2. It will obstruct commerce, by interposing the obstacle and delay of a draw. The bulk of foreign commerce is carried, in ships of the heaviest burden, above the probable line of the bridge. Some measure of the obstruction to commerce may be deduced from the fact that about 30,000 vessels of all sorts pass the locality of the bridge yearly.

3. It may cause injury to navigation by the formation of deposits in some part of the harbor, on account of diminishing the water-way and increasing the scouring effect of the tidal currents in the channel-way at the site of the bridge; and also, by diminishing the tidal action in the

upper part of the harbor, it will impair the general effects of the currents which now maintain the channel.

4. It will lessen the anchorage ground in the harbor.

In addition, there are local objections more or less serious in their nature.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. of Engineers, Commanding.

Major General JOHN M. SCHOFIELD,
Secretary of War.

R 7.

BOSTON, MASS., *June* 30, 1868.

GENERAL: I have the honor to acknowledge the receipt of your letter of June 24th, inclosing a copy of a communication from the chairman of the Committee on Roads and Canals of the United States House of Representatives, in relation to the proposed bridge between Boston and East Boston, and directing me to report as fully as possible upon the points of inquiry therein contained.

In accordance I have the honor to report as follows with respect to the effect of the proposed bridge:

1st. As to "the effect upon the navigation of the harbor." The plans of Mr. T. Willis Pratt, mentioned in the act "To incorporate the Maverick Bridge Company," (copy inclosed,) contemplate the construction of a wire suspension bridge resting upon three or four large piers of masonry. The bridge is to have a pivot draw of 380 feet in length, thus allowing a passage on each side of the pivot pier of 150 feet. It is proposed to open and close this draw by machinery, and also to employ a steam-tug to facilitate the passage of vessels.

The records of the drawkeepers at the bridges across Charles and Mystic rivers give the following as the number of vessels that have passed in the last year:

	Openings.
Chelsea bridge, south draw	5,400
Chelsea bridge, north draw	1,250
Meridian street bridge, East Boston to Chelsea	1,336
Charles river bridge, Boston to Charlestown	8,500
Total openings of draws in one year	16,486

The number of vessels that pass the line of the proposed bridge, going to the wharves in Boston, Charlestown, East Boston, and Chelsea, is at least equal to the above number that passed draws, viz, 16,486, giving the number of vessels that will pass the draw of the proposed Maverick bridge as 32,972.

The drawkeepers report that the time occupied by the vessels, which are schooners and others of light draught, in passing their draws, varies from two to 15 minutes, and averages at least five minutes.

At the new railroad bridge across the Merrimack at Newburyport, the time occupied in merely opening and closing the draw of 190 feet in length, without waiting for the passage of a vessel, is 4½ minutes.

The vessels that are to pass the Maverick bridge are the largest that

enter the harbor, being those of the India trade, and others of equally heavy tonnage, that have their wharves in Boston from Battery wharf around to the Charles river bridge, and the vessels of war of the navy. These heavy vessels, difficult of navigation at the best in a limited space, will be still more difficult to manage in passing the draw at the low rate of speed necessary to guard against serious accidents, and in the increased velocity of the current caused by the piers.

It is not unreasonable, then, to estimate that with all the advantages of steam in maneuvering the draw and towing vessels through, the time consumed in opening the draw, passing the vessel, and shutting it, will be at least five minutes.

This will amount to 164,860 minutes in the year, or 452 minutes, equal to seven hours and 32 minutes, in each day. The transit across the bridge will thus be interrupted for nearly eight hours each day, and will consequently almost totally interrupt travel. This is supposing that the transit is made subordinate to the passage of vessels. But the same interests that have carried the necessary bill through the legislature and brought it before Congress may be able to cause the passage of vessels to be made subordinate to transit across the bridge, and to limit the time for the opening of the draw and passage of vessels, and even to terminate in establishing a closed bridge. Whether it be ever carried to this extent or not, it is evident that the proposed bridge will be at the best a serious obstruction to navigation, not only in the time that will be consumed in passing the draw, but in the positive dangers resulting to vessels from collisions with each other, or with the piers or draw of the bridge.

A heavy frigate striking a pier, while passing at a speed of four miles an hour, would have momentum sufficient to overturn it, but at the same time it would probably be itself crushed in and sunk.

Every bridge is more or less an obstruction to navigation; but in this case, with a bridge across the best and most frequented part of the harbor, over a part of the best anchorage ground for heavy vessels, and on a line across which pass daily ninety vessels, the majority of which are of great tonnage, engaged in the foreign trade, or United States men-of-war, the obstruction becomes greatly aggravated, and of serious and almost fatal effect.

The space occupied by the piers will cause a corresponding diminution of the water-way, and an increased velocity of the current immediately between the piers. This will scour out the material of the bottom at the bridge, and convey this material to the distance from the bridge where the original velocity of the current is resumed. I calculate this increased velocity at the bridge to be four-tenths of a mile an hour, and that the scourings will be deposited within 2,000 feet. This, unfortunately, will place the deposit of the ebb tide in that portion of the anchorage which is now the most valuable for heavy vessels, being the deepest, so that ultimately this deep and valuable portion may be filled up so as to be no longer of the requisite depth for this large class of vessels. This would be an injury to the navigation of the harbor, the extent of which can hardly be estimated.

2d. As to "the area of anchorage ground," it will be seen by the sketches inclosed that the area of anchorage ground for large vessels, lying within the five-fathom curve, extends from a short distance above the most northerly of the proposed positions for the bridge, to some 1,500 below the most southern position. In either of the proposed positions it will pass over a portion of the best anchorage ground in the harbor.

Allowing 40 fathoms' scope of chain for a vessel of the Dictator class, which is considered absolutely necessary by pilots, and a length of 324 feet, which is the length of the Dictator, it will require an area of 584 feet radius to allow such a vessel to swing to her cable; but as no vessel should be anchored so as to strike the bridge in swinging, or, in case of the Dictator, within 584 feet on either side, the proposed bridge will take from the available anchoring ground for large vessels [584 × 2 × 40] × 1,500 = 1,812,000 square feet, or nearly 2,000,000 *square feet of the best anchoring ground* in the harbor.

This takes nearly one-half of all the available anchorage ground for the heaviest class of vessels, as will be seen from the space inclosed within the five-fathom curve on the sketch. And even the remaining space for large vessels will be further limited, in time, by the deposition of the scourings between the piers of the bridge as described above.

3d. As to the effect "upon the rights and interests of the United States in the Charlestown navy yard," I inclose a copy of "An act authorizing the United States to purchase a certain tract of land in Charlestown for a navy yard," passed (by the Massachusetts legislature) June 17, 1800.

Under this the land has been acquired, the buildings and wharves constructed, at an expense of about $30,000,000. The value of this property as a navy yard will be vastly diminished by the proposed bridge, which will so impede the ingress and egress of vessels of war as eventually to force the government to remove the yard to some more accessible harbor. The United States would thus, in addition to being deprived of its right to pass freely to and from the ocean which it had at the time of the establishment of the yard, be also forced to relinquish a portion of its property, and all the advantages of the establishment as a complete depot of stores and equipments. Even if it be retained as a navy yard after the proposed bridge be constructed, its value will be largely reduced. No vessel can pass to or from the yard without detention, and possibly serious damage.

In time of war, these delays and damages may prejudice operations to an extent that can hardly be estimated, but which must be very great. And if at a critical moment a secret enemy in our midst should blow the draw into the stream, its removal would delay the passage of every man-of-war for weeks; such a delay at a preconcerted moment might jeopard the loss of a fleet or the safety of a city from bombardment.

As a local measure, the construction of the bridge will have the effect to enhance the value of property in East Boston, and to reduce the value of property in Charlestown and Chelsea, and especially the wharf property in Boston west of the proposed bridge. The general effect will therefore be simply to transfer a portion of the money value of property from one section to another; taking from the property-holders in Boston and Charlestown to give to those in East Boston.

I inclose with the copy of the act to incorporate the company to build the proposed bridge, which was finally passed over the governor's veto, a copy of this veto, in which Governor Bullock gives many excellent and strong reasons for his dissent to the measure.

The Board of Harbor Commissioners are also decidedly opposed to the construction of this bridge, believing it to be injurious to the navigation of the harbor and to the interests of commerce.

It is a singular coincidence, that while the United States is expending nearly half a million of dollars in the preservation and improvement of the harbor, and in removing obstructions from its channel, the State should

(Senate 311, as amended by the Senate and passed to be engrossed.)

COMMONWEALTH OF MASSACHUSETTS.

In the Year One Thousand Eight Hundred and Sixty-Eight.

AN ACT to incorporate the Maverick Bridge Company.

Be it enacted by the senate and house of representatives in general court asse by the authority of the same, as follows :

Section 1. Gilbert E. Pierce, Nehemiah Gibson, Samuel Hall, Nathanie Charles R. McLean, Jeremiah H. Pote, Abraham S. Foss, their associates and s are hereby made a corporation by the name of the Maverick Bridge Company, wi powers and privileges, and subject to all the duties, liabilities, and restrictions se the sixty-eighth chapter of the General Statutes.

Sec. 2. The said corporation is hereby empowered and authorized to erect over the water between the mainland in the city of Boston, and East Boston, a chase or otherwise take and hold such real and personal estate as may be prope purpose, except that the property of the East Boston Ferry Company, and that by them, shall not be so taken, unless the said city shall so direct; and shall perm ferry company to run their boats between the landings formerly occupied by th Ferry Company, free of charge, and keeping the same in repair; and in that case Boston Ferry Company are hereby authorized to run their ferry between said landi capital stock of this company shall not exceed fifteen hundred thousand dollars, di shares of one hundred dollars each.

Sec. 3. The said corporation shall be holden to make compensation to any corporation whose real estate shall be taken for the uses aforesaid; and if there difference of opinion as to the value of the same, the said corporation shall pay the damages as shall be estimated by the board of aldermen of the city of Boston, party, if dissatisfied with their estimate, may apply to the superior court next t within and for the county of Suffolk, after said estimates shall have been known and thereupon the same proceedings shall be had as in case of estimating and payment of damages for laying out ways in said city of Boston.

Sec. 4. The said corporation shall construct the piers of said bridge of such size, shape, direction, and position respecting currents and channels, and the sa with a draw at right angles with the channel as near as may be, and with such acc tion for the passage of vessels through the same, as the mayor and aldermen o city of Boston, on consultation with the harbor commissioners, shall direct or but substantially in conformity to the single-draw plan of T. Willis Pratt, or such ments as may be made thereon; and in all other respects shall construct the same proval of said mayor and aldermen: and shall provide and maintain a suitable s boat, or such other aids to the passage of vessels through the draw of said bridge other purposes, as the said mayor and aldermen shall from time to time direct.

nually of all receipts and disbursements on account of the same, and of keeping it open and in order for public travel, which books of account shall be at all times open to the inspection of said mayor and aldermen, or of any committee thereof; and a copy of said accounts shall be made annually in the month of January, and under oath of the president and treasurer of said corporation, to the board of aldermen of said city of Boston, to and including the thirty-first day of December in each year, and a duplicate copy of the same annually filed in the office of the secretary of the Commonwealth.

SEC. 7. Whenever the receipts of said corporation shall have reimbursed to said corporation the moneys expended by them in the construction of said bridge, its furnishings and equipments, and in keeping the same in good repair and condition, with interest on said expenditures at the rate of eight per cent. per annum, the said corporation shall thereupon immediately, in writing, notify the said board of aldermen of said city of that fact, and shall thereupon offer the said bridge, its furnishing and equipments, to be surrendered to the said city of Boston, to be, and if accepted by the said city the same shall be, forever thereafter maintained as a free bridge by the said city at the public expense.

SEC. 8. The said city of Boston is hereby authorized, if they shall so elect and determine by a major vote of the two branches of the city council in concurrence, to assume and take the franchise granted by this act, with all the rights and privileges belonging to the same, and shall thereupon proceed forthwith to construct the said bridge as a free bridge, at its own expense, and for that purpose shall have authority to issue from time to time coupon bonds, notes, scrip, or certificates of debt, as said city council shall, by the major vote thereof, fix and determine.

SEC. 9. The said city of Boston, by a vote of the city council as aforesaid, may at any time, during the continuance of this charter, purchase and take of said company the said bridge, and all the franchise, rights, privileges, and property of the said company, by paying or offering to pay them therefor such sum as will reimburse them the amount of moneys expended by them in and upon said bridge, its furnishings, equipments, and repair as aforesaid, with eight per cent interest thereon, and less the net profits of said corporation from tolls, as aforesaid, and for that purpose shall have authority to issue from time to time bonds, notes, scrip, or certificates of debt, as hereinbefore provided; and upon such payment or offer of payment, the said corporation shall forthwith, by proper instruments of title, surrender and convey to the said city the said bridge, with all the franchise, rights, privileges and property to the same appertaining, and the said bridge shall thereafter be maintained and kept by said city as a free bridge, at the public expense, as aforesaid.

SEC. 10. The said city of Boston, by a vote of the city council as aforesaid, may assume and take, or purchase of said company, the said bridge and other property as hereinbefore provided, and have and exercise all the rights, powers, and authority given to said company by this act, and subject to all the duties, liabilities, and restrictions herein contained, in such a manner and by such agents, officers, and servants as the said city council shall from time to time ordain, appoint, and direct; and shall have a right to collect and receive the same rates of toll as are allowed by the fourth section of this act to said company; provided, that whenever from the tolls collected on said bridge, or from other sources, the said city shall have been fully reimbursed all outlays and expenditures on account of said bridge, and the operation of the same, then the tolls on said bridge shall cease, and the said bridge shall ever after be maintained by said city as a free bridge.

SEC. 11. If said corporation or said city, as the case may be, shall neglect for the space of five years to build and finish the said bridge, then this act shall be void.

SEC. 12. Whenever two hundred thousand dollars of said capital stock have been actually paid in in cash, the said corporation may issue its bonds for an amount not exceeding 8 per cent. per annum, and not exceeding 50 years to their maturity, and secure the same by a mortgage of the said bridge, furnishings, and equipments, and of the franchise and privileges thereto appertaining.

SEC. 13. When the said bridge company shall have built the said bridge, they shall offer, in writing, to purchase of the East Boston Ferry Company the boats, with their appurtenances, then in use by them for ferry purposes; and in case the two parties fail to agree upon the terms of said purchase, the supreme judicial court, in term time or vacation, shall, on the application of either party, appoint three commissioners to appraise the same at their fair valuation for ferry purposes, and shall fix the terms of purchase thereof; and if the same shall be accepted by said ferry company, they shall thereupon cease to run and maintain a ferry between said Boston and East Boston, and the same shall thereafter be run by said bridge company, with all the rights and privileges now had and enjoyed by the said East Boston Ferry Company; but if the said ferry company shall refuse to sell as aforesaid, the said bridge company shall be held to no further obligations hereunder. And if said bridge company shall fail to pay to said East Boston Ferry Company the amount awarded by said commissioners within 90 days after their award shall have been accepted by the said court, then this act shall be void.

SEC. 14. This act shall take effect upon its passage.

SENATE, *May* 29, 1868.

Passed to be engrossed. Sent down for concurrence.

S. N. GIFFORD, Clerk.

[SENATE—No. 338.]

COMMONWEALTH OF MASSACHUSETTS.

EXECUTIVE DEPARTMENT,
Boston, June 11, 1868.

To the honorable Senate:

I herewith return to the senate, in which it originated, a bill entitled "An act to incorporate the Maverick Bridge Company," which I am unable to approve. The late period of the session at which this very important measure has been enacted, at a time, too, when numerous other enactments of great importance are presented to the executive for revision, the consideration of which requires time for proper investigation, prevents me from making to your honorable body so full a statement of the reasons which compel my dissent from this bill as would otherwise have been possible. Passing by, therefore, various minor objections to details of the bill, which, under other circumstances, I should suggest to your attention, the main reasons which compel my dissent are briefly these:

First. I am not satisfied that the proposed structure will not lessen the depth of water in the ship channels of the harbor by shifting the places of deposit of the material which is brought down by the tidal and river currents, and without being so satisfied, I can under no possible circumstances approve of its erection.

I am advised by Professor Benjamin Peirce, the director of the United States coast survey, (whose capacity to pass an intelligent judgment on the question is indisputable, and who, as a citizen of Massachusetts, long residing in the immediate vicinity of Boston, can have none but true interest of the commercial capital at heart,) that such, in his opinion, will be the result. And I am further advised that such, also, is the opinion of other eminent scientific authorities. I have no need to enlarge on the detriment which the structure will produce to the welfare and importance, not only of Boston and Massachusetts, but of all New England, if it shall be erected and be found to cause such an effect. The local benefits which it would confer would be but slight compensation for the misfortune of shoaling by ever so few inches our harbor channels.

Second. I am advised by large deputations of eminent merchants of Boston and its vicinity that the proposed structure will injure the maritime commerce of the capital in various ways, among which are the following:

(1.) By lessening the anchorage ground in the harbor, which is already very limited.

(2.) By diminishing the area of wharfage at and near both termini of the bridge. And I desire to call your attention to the fact that the bill does not designate the points of termination of the bridge on either side of the harbor, but leaves to the option of the corporators the selection of them anywhere along a line of several hundred yards on each shore.

(3.) By diverting foreign commerce to other localities, perhaps to other ports, as the wharves now principally devoted to that branch of our trade, which is carried on in vessels of the greatest draught, are situated above any line on which it is probable that the bridge would be built.

(4.) By the diminution of all the various and extensive trade along the shores of Boston, Charlestown, Chelsea, and Cambridge, which lie above the bridge, certain to result from interposing such an obstacle, which, according to this bill, is not to be raised to a height sufficient to permit the free passage of any class of vessels, but is to be traversed by them only by means of a draw.

Third. I am informed by the commandant of the navy yard at Charlestwon that certainly the interests, and, in his opinion, the rights of the United States in that establishment will be infringed by such a structure.

Fourth. The harbor commissioners of the Commonwealth, and the distinguished military and civil engineers who are engaged on the public works in the harbor, are unanimous in condemning the project as injurious on the foregoing and on other grounds, and to their judgment, in a matter so directly within the province of their investigation, I am constrained to render great deference, since I cannot regard it other than intelligent and impartial.

It is said that there are grave constitutional objections also to the assumption of power by the legislature of a State to authorize such an erection over navigable waters. But in the light of the decision of our supreme judicial court, in the case of the Commonwealth *vs.* The Proprietors of the New Bedford Bridge, 2 Gray's Reports, pp 346, 347, I do not doubt our right and power over the subject, provided our enactments do not interfere with the regulations of Congress; and neither can I doubt the right and power of Congress to interpose at its discretion, and overrule the legislation of the State. Nor have I doubt that if this bill shall, by your action, become a law, the interposition of Congress will be sought; and even if the structure were otherwise unobjectionable, I respectfully suggest whether, as the interests and rights of the federal government, not only as the guardian and regulator of commerce, but as itself the actual owner of an immense property at Charlestown and Chelsea and Watertown, are directly affected by the question, it would not be a suitable course to seek first the opinion of Congress, as a guide to the legislation of the Commonwealth.

Suggestions have been made from respectable and intelligent sources that this measure has been precipitated, and that the executive sanction should be withheld from the bill, in order to make delay: because the merchants of Boston have not believed that it was a serious project, and therefore have neglected to remonstrate with the legislature concerning it, as they otherwise might have done, and as it is represented they will do in the future. I hardly need to remark that to such suggestions I give no consideration, and that they deserve none: in the first place, as conveying an unjustifiable imputation on your honorable body, and in the next place, because no class in the community has any right to appeal to the executive for protection against its own negligence. I rest no objections to the bill on such grounds.

But in reference to a matter of such vast importance, which affects directly or indirectly the value of at least a hundred million dollars' worth of property along the shores of Boston and neigboring cities, enhancing it in some quarters, diminishing it in others, which brings us into positive conflict with the Navy Department of the United States, and into possible conflict with Congress, which is disapproved by the harbor commissioners and the engineers employed in the harbor of Boston; which is condemned by certainly a large part of the mercantile community as, on the whole, more injurious than beneficial, apart from any consideration of its effect on the depth of water in the channel; and which, more than all, in the judgment of competent scientific authorities, will result in shoaling the whole harbor; I am unable to give my approval, without further discussion and further information to enlighten my judgment than is now possible without delay.

I fully appreciate the local benefits which are expected to result from it to East Boston. I wish, for the prosperity of that locality, that it were possible to attain those benefits in some other way than at the risk of great injury to a community embracing more than the whole of this Commonwealth, and of which the people of East Boston are but a small fraction. But as, after such investigation as I have been able to make, such injury seems to be a probable result of the measure, I cannot give it my assent.

If, upon reconsideration, the general court shall be led to give such weight to these opinions as to concur in a postponement of the enterprise, I trust I may not be considered to exceed the limits of executive revisal in respectfully suggesting that the bill be referred to the next legislature, and that a commission be specially appointed, or the duty imposed on some existing commission, to investigate meanwhile, and report next January, upon all the grounds on which the project is now either opposed or advocated. Possibly, also, Congress at its present session might think advisable to appoint a commission in behalf of the United States, to act in concurence with our own. And if, in the light of the report of such a joint commission, the objections which it has been my duty to set forth shall be shown to be groundless, the measure can then be carried into effect with confidence in its beneficial results.

ALEXANDER H. BULLOCK.

AN ACT authorizing the United States to purchase a certain tract of land in Charlestown, for a navy yard.

SECTION I. *Be it enacted by the senate and house of representatives in general court assembled, and by the authority of the same,* That the consent of this Commonwealth be, and hereby is, granted to the United States, to purchase a tract of land situated in the northeasterly part of the town of Charlestown, in the county of Middlesex, adjoining and bounded on two sides by Charles and Mystick rivers, not exceeding 55 acres, exclusive of flats, for the purpose of a navy or dock-yard, or both of them, and erecting magazines, arsenals, and other needful buildings. The evidence of the purchasers aforesaid to be entered and recorded in the registry of deeds in the said county of Middlesex. *Provided, always,* (and the consent aforesaid is granted upon the express condition,) That this Commonwealth shall retain a concurrent jurisdiction with the United States in and over the tract of land aforesaid, so far as that all civil and such criminal processes as may issue under the authority of this Commonwealth against any person or persons charged with crimes committed without the said tract of land, may be executed therein in the same way and manner as though this consent had not been granted.

SEC. 2. *And be it further enacted,* That if the agent or agents employed for the United States, and the owner or owners of said tract of land so to be purchased, cannot agree in the sale and purchase thereof, such agent or agents may apply to any court of general sessions of the peace which shall be holden within and for the aforesaid county of Middlesex, which court, after due notice given to the said owner or owners, are hereby empowered and directed to hear and finally determine the value of the same tract of land, or any part or portion thereof, by a jury under oath, to be summoned by a sheriff or his deputy for that purpose, or by a committee of three persons, if the parties aforesaid can agree upon them; and the value thereof being thus ascertained by the verdict of such jury, or the report of such committee, who are also to be under oath faithfully and impartially to value said tract of land, or any part or portion of the same, and such verdict or report being accepted and recorded by said court, and the amount thereof being paid or tendered to the owner or owners of said tract of

land, or to the owner or owners of any part of said tract of land that shall have been thus valued, with his or her reasonable costs, the said tract of land or such parts of the same as shall be thus valued shall forever be vested in the United States, and shall and may be by them taken, possessed, and appropriated to the purchase aforesaid.

This act passed June 17, 1800.

APPENDIX R S.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., April 6, 1868.

GENERAL: My attention has been attracted to a report of Assistant Whiting, United States Coast Survey, upon an examination made by him of the harbor of Provincetown for certain State commissioners for Cape Cod, Massachusetts.

The statements of this report have an important bearing upon three points relating to the preservation of the harbor:

1. As to the protection on the seaward side of East Harbor. It is stated that a comparison of the survey of Major Graham in 1835, with that of the Coast Survey in 1857 and 1867, shows that the beach or dividing ridge has been worn away at one point by the waves and currents from a width at high-water level of about 300 feet in 1835 to less than 100 feet.

If this statement is really established by careful measurements, then, in addition to the planting of grass and catch-sands on the beach, a dike should be constructed across East Harbor at the narrow point near High Head, indicated by yourself and Colonel Blunt in 1866. You will please make such measurements as may be necessary to determine the question and report the result.

2. The second point is that a large deposit has been made in the harbor of Provincetown by the ebb tide from East Harbor, extending from the 6-foot curve to the 30-foot curve.

This question cannot be determined positively, except by measuring the direction and force of the currents at the surface and at the bottom through the flood and ebb tide, from the mouth of East Harbor at the bridge out to the 30-foot curve, where the deposit is said to end. Further, the effect of closing the mouth of East Harbor upon the flood current (which I suppose now sets into it from the southeast, and which, when the mouth is closed, may flow across the shoal lying west of the mouth of East Harbor and carry the material of that shoal southwestwardly into the best part of the harbor of Princetown) should be ascertained by measuring the direction and force of the currents during flood and ebb, at surface and at bottom, from the shore line to 30 feet depth on a line perpendicular to the shore about Moon Pond meadow; and similar current measurements from the shore line out to 30 feet depth, just west of the mouth of East Harbor. Similar measurements may be found desirable on another line further west.

3. The third point is the yearly extension of Long Point into the deep water. This is stated, from a comparison of the surveys already mentioned, at about eight feet per year.

It appears to me important to ascertain whether this extension is due chiefly to the current or to the waves. To determine this, the direction and force of the currents at surface and bottom during flood and ebb should be ascertained from the shore near Lobster Plain out to deep water, (say 100 feet depth;) and at the light-house out to about 100 feet depth, the same on a line in the direction of Long Point, the same out to deep water inside the harbor. And that in addition the direction

and force of the currents at surface and bottom during flood and ebb should be ascertained from the extremity of Long Point completely across the harbor on a line in the general direction of Long Point, and in such other lines as may be found necessary.

The action of the water through flood and ebb, inside and outside the harbor, around Long Point, should be carefully observed. It appears to me we should find, during portions of the flood and ebb, eddies inside and outside the point.

I would suggest, as the best means for measuring sub-currents, a sub-float with a large surface. and a surface-float with a very small extent of surface, the two being connected by a very fine wire, or horse hair, thread, &c.

Tin cylinders for sub-floats, open at top and bottom, have been found to answer well. Hollow India-rubber balls, weighted, may be found to answer. To determine preliminarily the fact of the existence and general direction of the sub-currents, a sub-float suspended by a wire held in the hand has been found a ready means.

Tidal observations should, of course, accompany the current observations.

If desired, the actual difference of level of high water in the sea outside and the surface of the water at the head of East Harbor at the same moment of time may be determined.

A printed map of Provincetown harbor has been marked with lines indicating where it is suggested current observations should be made.

It is suggested that Brevet Major Burroughs, now under your orders, should be employed by you to make these observations. They should commence immediately, and be completed at the earliest day practicable, and report made of results, with your views and recommendations. The expense will be borne by the appropriation for the preservation of Provincetown harbor until appropriation is made for surveys on the Atlantic coast.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Brevet Major General H. W. BENHAM,
Colonel of Engineers, Boston, Massachusetts.

R S 1.

BOSTON, MASS., *August* 26, 1868.

GENERAL: I have the honor to report as follows in relation to the work executed for the protection of Provincetown harbor during the year ending June 30, 1868, or rather until June 18, when the work was, by your orders, transferred to the charge of Brevet Major General Foster.

I would state that the work which had been executed at Beach Point under my direction during the year 1866 had received much injury during the violent storms of the winter of 1866 and 1867, although it had afforded a very considerable protection to that peninsula; yet some two-thirds of this bulkhead had remained in an essentially good condition, collecting and securing the sand in front of it, especially near the south-east extremity; and at Long Point, while the bulkhead constructed in 1866 to protect the shore opposite the larger or 5-gun battery, about one-third of a mile from Long Point light, was in excellent condition, having, with its jetties, stood secure, and largely accumulated the sand in front, the old or first bulkhead near the light-house, erected in 1852, was almost

entirely destroyed during the storms of the winter. I therefore, in July, 1867, as the appropriation bill required, advertised for proposals to rebuild the last-named work, and to place a riprap protection of stone in front of it, as also to repair and extend to the northwest, towards the inlet, the bulkhead which had been constructed at Beach Point in the year previous; and contracts were duly made for the execution of this work at reasonable prices.

These bulkheads were to be virtually fences of 2-inch plank, 6 to 7 feet high, with posts every 4 or 5 feet, set one-half of their length in the sand, each post being held to the rear by two braces of 10 and 15 feet dovetailed on, and held by pickets to cross-ties, which braces were covered well with sand planted with beach grass, while in front was a system of brace jetties, or "catch-sands," every 20 or 25 feet, extending out some 25 to 30 feet, while about every fourth jetty had a length of some 50 to 60 feet.

These jetties were constructed of posts well set in the sand, and planked on both sides and on top. This plan was pursued with the bulkheads at both places, and this timber work was completed very satisfactorily last autumn. At Long Point the new bulkhead was built at a length of 775 feet with 24 jetties, and about 500 tons of large rough stone placed there, and though only a portion of this large rough stone, about one-fourth, was delivered for the riprap protection to the bulkhead at Long Point, as was alleged on account of the great scarcity of vessels, yet the portion delivered has done excellent service in securing the bulkhead and in aiding in the accumulation of the sand there. While at the bulkhead above, or at the larger battery, I found, at my inspection in June of this year, that the half-tide line had been carried out over 200 feet in front of the bulkhead within the less than two years that it had been constructed, and the bank at high tide here had largely increased in front of this work, especially near the extremities, while the large jetties were all well filled with sand.

At Beach Point the extension of the old bulkhead was for 775 feet with 23 jetties, while the old portion of the work was repaired where needed; seven new jetties were built and old ones repaired for an extent of about 750 feet; and here I found at the same time a most favorable condition of things also, the sand having formed out in front of this work for 400 feet in length at the southeast part, even to the extent of 150 feet at the actual extremity, while all the jetties along the whole length were well filled with sand, sustaining the main bulkhead and supporting the roadway works of the town's people in rear; the superintendent of which road work, happening to meet me there, expressed the strongest satisfaction and confidence in the work and its plan. As I found, however, at my last visit, that the sand was wearing away by some of the recent winds from the northwest end of this work, although not the slightest injury had occurred to the bulkhead or its jetties, I then judged, as I have since stated to General Foster, that an extension of about 200 yards to the northwest or towards the inlet should be added at once to this bulkhead, with an arrangement if possible for the delivery of about 15 or 18 cubic feet of rough stone per running foot, as a riprap, to extend at about the ends of the jetties, or just within them, along the whole length of the old and new work. I believe that a protection of this kind would suffice for the security of this beach, and perhaps render unnecessary the very expensive framed timber cob-work loaded with stone, which perhaps is the only construction that could be relied upon as *probably sure* to resist the waves in this position. The work, therefore, which had been done during the year is as follows: At Beach Point the repairs, with several new jetties of about 750 running feet of the bulk-

head of 1866, and its extension of about 755 running feet to the northwest, with 23 new jetties; and at Long Point the old bulkhead near the light has been rebuilt for 775 running feet, with 24 new jetties, in front of which has been placed about 500 tons of large, rough stone for a riprap breakwater.

An abstract of proposals and contracts is respectfully submitted, as also a statement of the fund received, expended, &c., also letter of the collector of the district, F. Swift, giving information in relation to articles Nos. 6 and 7 of the circular of June 10, 1868.

Statement of funds available, expended, &c., for the fiscal year ending June 30, 1868, on account of the preservation of Provincetown harbor.

In the United States treasury July 1, 1867	$40,068 44
In hands of the United States assistant treasurer at Boston and New York at same time	3,000 00
Derived from appropriation for the work on the seaboard	225 24
Total available for the fiscal year ending June 30, 1868	43,293 68
Expended during the year	$6,542 42
Transferred to General J. G. Foster	6,682 82
Undrawn from the United States treasury	30,068 44
Agreeing with total available for the year	43,293 68

I am, sir, very respectfully, your most obedient servant,

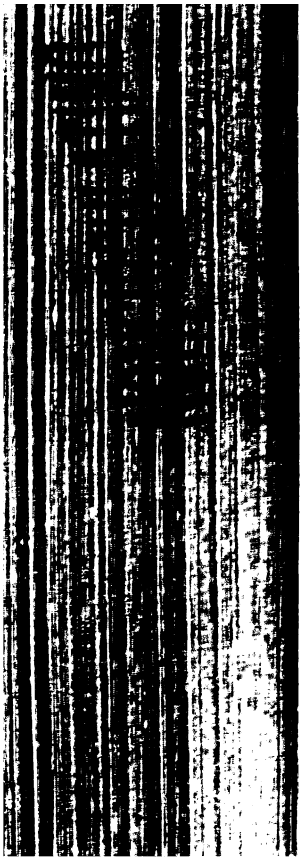
H. W. BENHAM,
Colonel of Engineers, Brevet Major Gen. U. S. A.

Major General A. A. HUMPHREYS,
Corps of Engineers.

NOTE.—The sum of $3,482 71, not included in the above statement, belonging to the appropriation for works on the seaboard, and which was applicable to preservation of Provincetown harbor when received, still remains in my hands in the office of the United States assistant treasurer at Boston.

Abstract of proposals for work for preservation of Provincetown harbor during the year ending June 30, 1868.

	Names.	
	J. H. Blaisdell & Co.	Chas. Emison.
For building of bulkhead, &c., as per advertisement of August 12, 1867:		
Lumber built into bulkhead and jetty, as per M feet	$28 00	$40 00
Spikes, per 100	7 00	6 00
Filling in rear, per cubic yard	25	25
Setting out beach grass, per 100 square feet	10	1 00
Setting out beach grass, per day	2 25	4 00
One horse team and driver, per day	3 75	6 00
Rough stone, if landed on beach from vessel, per ton	2 50	3 00
Rough stone, if placed on rafts, per ton	2 75	.....



schedule.

H. W. BENHAM,
Brevet Major Ge

CUSTOM-HOUSE, BARNSTABLE,
Collector's Office, August 23,

SIR: In reply to your letter of August 19 I beg leave to state: 1
revenue collected at the port of Provincetown for the year endi
30, 1868, was $4,378 53; 2d. It is difficult to estimate the amount
merce and navigation that would be benefited by the harbor i
ments now being carried on there, as but a small proportion of the
which enter the harbor belong there. The Provincetown vessels
210, with an aggregate tonnage of 10,105.56; but I have seen c
vessels in the harbor at one time, and the vessels which use it a
bor of refuge and which would be imperilled by its destruction
numbered by tens of thousands. They sometimes stop in port b
hours, and few of them regularly enter and clear.

Very respectfully, your obedient servant,

F. SWIFT, *Col*

R S 2.

BOSTON, MASS., *June* 30,

GENERAL: I have the honor to report that on Wednesday
week I proceeded to Provincetown with Major Burroughs, and
that and the two following days made a thorough examinatio
points exposed to injury from the waves and currents.

I found at Long Point that the shore needed at present no
protection than what will be afforded by the completion of the a
of stone ballast, extending to the westward from the base of t

Upon the outer beach, at the points marked A B and C upon Colonel Graham's sketch accompanying his report of November 28, 1865, I found that the encroachments of the sea had been sufficient to afford reasonable grounds for the apprehension that exists in some minds that it will break through at one of those points. I therefore decided, in order to allay this apprehension, and to guard against the possibility of this danger, to construct at once, as authorized by your letter of April 8, 1868, to General Benham, a secure dike across the salt meadows, at what is called the "wading place," situated at the narrowest part, opposite High Head. The plans are now being made for both works, and advertisements for proposals will at once appear.

To-morrow Major Burroughs will proceed again to Provincetown to commence the current observations directed by your letters to General Benham, of the 6th of April and the 20th of April, 1868.

Messrs. Paul Hill and James Gifford, State commissioners, were present, and accompanied me to several of the exposed localities. They expressed gratification at the contemplated protection, and a desire that the operations under the State and United States appropriations might be conducted in harmony.

On the 28th instant, General Benham turned over to me the balance of the appropriation for "Preservation of Provincetown Harbor" in his hands, $5,682 82 in amount, and a war warrant for $3,000 on account of appropriation for "Examinations and Surveys of the Atlantic Coast."

I remain, general, very respectfully, your obedient servant,

J. G. FOSTER,

Brevet Major General U. S. A., Lieutenant Colonel Engineers.

Brevet Major Gen'l A. A. HUMPHREYS,

Chief of Engineers, Headquarters Corps of Engineers,

Washington, D. C.

APPENDIX S.

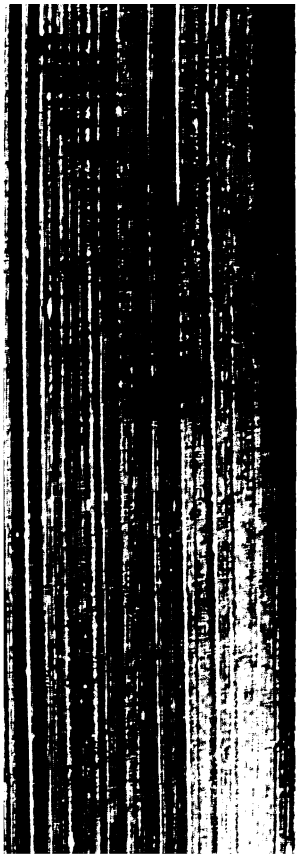
BOSTON, MASS., *August* 25, 18 6

GENERAL: I have the honor to report as follows in relation to the operations on the sea-walls of Deer and Lovell's islands for the year ending June 30, 1868.

In relation to the Deer Island sea-walls, as was mentioned in my last annual report, the prosecution of the rebuilding of the wall of the Middle Head was going on successfully at the commencement of the year in July, and it was pushed forward to the completion by the close of the month of August, of all that now appears necessary on the wall of that head, making altogether about 540 running feet rebuilt there, of which 200 running feet was built within this fiscal year.

The wall of the South Head was commenced and completely rebuilt in a substantial manner, comprising about 420 running feet, by the close of the last working season. The work of that portion of the fiscal year thus comprising about 620 running feet, and with the work of the former year making about 960 running feet rebuilt on both the walls of the Middle and South Heads, while a quantity of stone has been purchased and received for the jetties required.

Upon the opening of the season this year, and finding but a few thousand dollars only remaining or not enough to fairly commence operations with, of the appropriations made previous to the last one, which



running feet on the South Head, and about 206 running feet North Head, or 826 running feet altogether during the year.

This contract, I may state, has been taken at such a reasona as to require much vigor and judgment in its execution to ordinary profits usually expected. And if there is a failure respects, it is still trusted that the amount guaranteed by th $11,000, or about 33 per cent. of the contract price, if it should be able in case of failure as expected and as legally due, will w amounts as I shall have still unpaid from the funds appropriat suffice for the completion of the work required, so that I do think it necessary to make further estimates for this work.

For the walls of Lovell's island, proposals were advertised f contract made in July, 1867, for the delivery of the cut-stone fa about 800 running feet of wall, to protect the southeast bluff, to have four courses averaging two feet each above the foundat the necessary split stone for jetties to this wall, and for the prote the old wall of the North Head were provided for by the same co The greater portion of the cut stone and a part of the jetty st delivered upon the river beach, near the southeast bluff and a t laid to the line of the wall, and the stone distributed along the the close of the last working season. The contractor report great difficulty in obtaining vessels as the cause of the non-del the whole as contracted for last autumn. Some further work w on the buildings there, a small barn constructed, and then the t was mostly taken up and the derricks, &c., stored for the winte

In the opening of this season, as the funds of the last appro required the wall to be built by contract, and as the rate at wh Deer Island sea-walls had been contracted for, with the furth pledged by the bond, appeared to be sufficient to insure the cons of that wall and to leave enough available to build this wa Proposals were advertised for in May, and a contract made construction of this wall and its jetties, which though at higher rates than those for the Deer Island wall are still not unrea

As the funds of these two works have always been connected or made in the same appropriation, I give the following summary or cash statement of the funds received and expended during the fiscal year:

Statement of funds received and expended on the sea-walls for Deer and Lovell's islands for the fiscal year ending June 30, 1868.

In Treasury of the United States, July 1, 1867, of former appropriations		$32,000 00
In Treasury of the United States, July 1, 1867, of appropriations of March, 1867, $25,000 for Deer and $25,000 for Lovell's		50,000 00
Received for sale of public property		448 79
In hands of assistant treasurer at New York and Boston, July 1, 1867		2,544 35
Total available for the fiscal year ending June 30, 1868		84,993 14
Expended during the year		32,029 05
In the United States Treasury, July 1, 1868	45,448 79	
In hands of assistant treasurer at Boston and New York	7,515 30	
Leaving available for the work, June 30, 1868		52,964 09

I am, sir, very respectfully, your obedient servant,

H. W. BENHAM,
Colonel of Engineers, Bv't Maj. Gen'l U. S. A.

Major General A. A. HUMPHREYS,
Chief of Engineers.

Abstract of proposals for material and workmanship for Deer and Lovell's islands, Boston harbor, during the year ending June 30, 1868.

1. For delivery of stone for sea-wall at Lovell's island and jetties at Deer and Lovell's islands, as per advertisement dated June 22, 1867:

Names of bidders.	SEA-WALL.		Jetties, cubic foot.
	Coping, superficial feet, face measure.	Facing, superficial feet, face measure.	
Edmund Langley	$2 70	$1 60	$0 35
James M. Andrews	3 20	1 65	.....
F. K. Ballan	3 99	2 33	39
E. C. Sargent	4 25	2 25	41
Charles T. Dorsey	.....	.....	40

A contract was concluded, in accordance with his offer as above, with Edmund Langley.

H. W. BENHAM,
Brevet Major General.

Abstract of proposals and contracts—Continued.

2. For the reconstruction of main wall, rebacking main wall, and constructing jetties at Deer island, Boston harbor, as per advertisement dated March 26, 1868.

Names of bidders.	Rebuilding main wall, per lineal foot.	Rebacking main wall, per lineal foot.	Concrete, for jetties, per cu. yd.	Dry masonry, per cubic yard.	Blacksmiths, per day.	Laborers, per day.	Masons, per day.	One-horse team drivers, per day.
Samuel R. Edwards*	$19 00	$12 00	$4 00	$1 50	$2 50	$2 25	$3 75	$3 50
Frank W. Blaisdell, I. Oliver Trepethent	19 25	15 20	6 25	3 50	4 00	2 25	4 50	4 00
James Andrews‡	24 50	§11 25	6 00	3 00	3 00	2 50	3 00	3 50
Patrick Wheeler‖	32 00	.....	.....	.....	.....	.....	.....	.....
James Phillips	60 00	40 00	7 00	6 00	3 25	2 10	3 75	.....

CONDITIONS ATTACHED TO OFFERS.

*Other parts to be accepted only on condition of the acceptance of the rebuilding and repairs of the main wall.
† On condition that we take the whole if awarded.
‡ All other bids are offered on condition that the building of main wall is accepted.
§ Specified "per yard," supposed to mean "lineal foot."
‖ No guarantee furnished; therefore does not conform to advertisement.

A contract was concluded with Samuel R. Edwards in accordance with his offer as above.

H. W. BENHAM,
Brevet Major General.

Abstract of proposals and contracts—Continued.

3. For construction of sea-wall and jetties at Lovell's island as per advertisement of May 30, 1868.

Description of work and material.	NAMES OF BIDDERS. Chas. F. Derry and Chas. H. Edwards.	George W. Johnson.
For main wall, per lineal foot	$18 87½	$29 00
For stone masonry and jetties, per cubic yard	2 75	5 00
For concrete, per cubic yard	4 00	10 00
For laborers, per day	2 50	2 60
For blacksmiths, per day	3 50	5 00
For masons, per day	4 50	5 00
For two yokes of oxen and driver, per day	.....	10 00
For one yoke of oxen and driver, per day	5 00	7 00
Horse team and driver, per day	4 00	6 00

The conditions were on the part of Messrs. Derry & Edwards that the whole be accepted, and of Mr. Johnson's that the bid for the main wall be accepted.

A contract was concluded on the terms of their offer, as above, with Messrs. Charles F. Derry and Charles H. Edwards.

S 1.

BOSTON, MASS., *August* 22, 1868.

GENERAL: I have the honor to make the following report of operations on the sea-wall for the protection of the Great Brewster island, for the year ending June 30, 1868.

As stated in my last annual report, (of the date of September 6, 1867,) the wall for the protection of the south head of this island was then completed, and the main wall, except paving in rear, was about finished on the whole of the east or most exposed face of the main or north bluff, and a return has been made at the north short face, or at the last most exposed angle of the work. This wall upon this short face was continued through July into August to about the completion of that face of nearly 150 running feet, when the former funds of the wall being about expended, and the new appropriation requiring all work to be given out by contract, proposals were called for by advertisement for the completion of the work to the extent of the funds available. One offer only was received, and that from the overseer who had previously carried on the work, so that the operations, as it happened, continued without interruption until the near exhaustion of the funds in November. During this time the main wall of this north head, with its coping, was completed as far as was projected in the original designs for this work; that is, as far around from the east and north to the northwest sides of the island as the bluffs or slopes of the hill show signs of recent abrasion by the sea, and the wall was terminated and built into these banks, where the slopes in rear and beyond appear to be continuously well grassed. The layers of large boulders left or deposited there for many years past, upon the shores near high-water line, beyond or south of the termination of this wall upon this west or inside, appear to offer all the remaining protection that now seems necessary, and thus the bluffs of the island, I trust, are essentially secure from further abrasion.

The amount of wall constructed during the year since June, 1867, is 550 running feet, making 1,655 running feet of protection for the north head, and with the 885 running feet of heavy sea-wall at the south head gives about 2,540 running feet of main wall altogether, besides one large jetty at south head now constructed for the protection of this island.

I regret to say, however, that the increased cost of the work at the contract prices absorbed a portion of the funds that I had estimated to complete this wall of the north head, and that the filling and paving in rear of the wall from the northeast angle, for over 500 running feet, could not be completed; and this portion of the wall is now standing with more than one-half of its upper portion entirely unsupported by even earth in its rear. It happens, however, fortunately, that this is not the part most particularly in danger from the storms of the open ocean; though this portion should be filled up to the level of the coping as nearly as practicable, which can be done at but small expense; and the heavy paving, a large portion of which is on hand at the island, the most of it hauled to its position in rear of coping, should also be set as early as funds can be obtained, and a paving of boulders will probably suffice on the north and northwest lines of the wall where least exposed to the heavy dash of the sea.

For completing this north head wall, for filling the unbacked portion of the wall with earth, and for setting the heavy paving on the most exposed parts on the east faces, and for a temporary protection to the gap between the north and south walls, with the construction of one or

two small jetties, as I have recently reported, the sum of $10,000 will be required. But for the closing of the gap of 250 running feet, which a continued observation of the effects of the sea confirms me in the opinion that it is indispensable, I would estimate, as last year, the sum of $22,500, *if executed by hired labor;* and for a strong jetty at the termination of the wall at the northwest side of the island $2,500, or altogether to complete this wall, $25,000.

I may repeat here that, though I find it infinitely easier and more agreeable for an officer to execute work by contract, as the last law required, I have a full certainty that, under ordinary circumstances, the work will not be as well executed with the same economy to the government; and though I have made some contracts at reasonable prices, and *one* below my own estimates even, I have yet to see the entire fulfillment of these contracts, or the *prospect* of it, even, in the case of the one last referred to. The abstract of the contract made with Mr. James Phillips, and not entirely completed, though given up by him from the failure of the funds, is hereby respectfully forwarded.

The following is the report of funds for Great Brewster island sea-wall, as available, expended, and on hand:

In the United States treasury July 1, 1867, less amount of taxes paid direct from treasury	$25,218 44
Of which there was due from the United States	9,308 40
Leaving balance from new appropriations	15,910 04
Appropriation of March, 1867	25,000 00
Received from sale of public property	251 21
Total available for fiscal year ending June 30, 1868	41,161 25
Expended during the year	$40,343 75
In the United States treasury July 1, 1868	$269 65
In the hands of assistant treasurer at Boston and New York	547 85
	817 50

I am, sir, very respectfully, your obedient servant,

H. W. BENHAM,
Colonel of Engineers, Brevet Major General U. S. Army.

Major General A. A. HUMPHREYS,
Chief of Engineers.

Abstract of proposals for work on sea-walls at Great Brewster island during the year ending June 30, 1868.

For laying the masonry of the sea-wall and building a jetty, as per advertisement of August 2, 1867, James Phillips, (the only offer received:)

For laying the masonry of said wall, with its concrete backing, per superficial foot, face measure	$2 00
For laying the concrete foundation, per cubic yard	7 00
For excavating for foundation of said wall, per cubic yard	1 00
For filling in rear of said wall, per cubic yard	1 00
For laying the flagging in rear of coping, per square yard	5 00
For building the jetty at South Head	1,150 00
For masons, per day	4 00

For laborers, per day	$2 10
For one-horse teams, drivers, per day	3 50
For team and driver, per day	4 00

DETAIL FOR THE JETTY.

Excavating for the foundation stone, per cubic yard	$1 00
Laying the concrete, per cubic yard	7 00
Laying the boulders, per cubic yard	2 00
Laying dry masonry, per cubic yard	2 75
For jetty stone, per cubic foot	33

A contract was concluded with James Phillips in accordance with his proposal.

H. W. BENHAM,
Brevet Major General.

APPENDIX T.

I. *Report on the Saco river improvements for the year ending June 30, 1868, by Brevet Brigadier General George Thom, Lieutenant Colonel of Engineers.*

By acts of Congress approved June 23, 1866, and March 2, 1867, appropriations amounting to $80,000 have been made for this work.

The plans, which have received the approval of the department, consist in the rebuilding of some of the most important piers in the river, the removal of sunken rocks near Little islands, and the construction of the breakwater near the entrance to the river.

At the beginning of the present fiscal year, one sunken rock near Little islands had been removed, and a contract had been made with Messrs. James M. Deering and John W. Deering, of Saco, Maine, for furnishing 50,000 tons (more or less) of rough stone for the breakwater near the mouth of the river, for $1 81 per ton of 2,240 pounds. At the close of the fiscal year ending June 30, 1868, the contractors had deposited 39,270 tons* of stone in position on the breakwater.

This work has been carried (in partial completion) from its shore end to the beacon on the inner end of the outer pier, being a distance of 2,550 feet, and up to a general level of 10 feet above mean low water, or one foot above mean high water.

This has closed the old channel (as was intended) and formed a new one (as was expected) much more uniform and direct along the inside of the breakwater as far out as the outer end of the old beacon pier, and is apparently improving out beyond that point, so that vessels now enter through the new channel, drawing as much water as before. But in order to fully realize the benefit to be derived from this important work, so as to have a direct, uniform, and permanent channel through the bar, (at the entrance to the river,) it is now evident that the breakwater will have to be extended to the spit about 800 feet beyond the outer end of the beacon pier. This extension will necessitate an increase in the original estimate for the work.

On the 24th of July, 1867, I entered into a contract for removing a large sunken rock near Little islands, with Mr. James M. Andrews, of Biddeford, Maine, for the sum of $2,000, he being the only bidder for the job. (See appendix marked I.) On the 8th of September the contract was satisfactorily fulfilled.

*On the 3d of July, 1868, 40,223 tons had been delivered, when operations on this work were suspended for want of funds.

manent completion of the Saco river improvement, as per previous estimates	$270,0
Additional amount required for its extension as above proposed	50,0
Total	320,0
Amount appropriated by acts of Congress approved June 23, 1866 and March 2, 1867	80,0

Additional amount required for completion of work $240,000, of v
$75,000 can be profitably expended upon it during the next fiscal ye

Available balance of appropriation July 1, 1867	$79,7
Amount available June 30, 1868	4,1
Amount required for year ending June 30, 1870	75,0

The works for the improvement of Saco river are located in the lection district of Saco, near the ports of Saco and Biddeford, M The nearest light-house is on Wood island, opposite the mouth of river, and the nearest forts are those in Portland harbor, about 15 distant.

The amount of revenue collected at Saco, (the port of entry,) as nished by the collector, was for the fiscal year ending June 30, $1,258 46. As to the amount of commerce and navigation that v be benefited by the completion of these works of improvement, repeat the information contained in my last annual report, viz:

At the inner harbor, which is inside the bar, the arrivals amou about 40 coal vessels, and about 150 to 200 vessels in the coasting t bringing general merchandise for Saco, Biddeford, and the back try, and carrying out timber, &c., exclusive of what comes by rail This port is the entry for the supplies, including the back distric a population of about 30,000, and is the natural shipping port o timber interest of nearly the whole of York county, except some t

The Saco ship-building company, also, has just fairly started, and will give a new impetus to commerce, as they obtain a considerable portion of their timber from the southern markets.

The improvements already made and now in progress may be regarded as permanent, and such as after completion will not require further expenditure.

The papers described as follows are hereto appended:

1. Abstract of proposals for each work, with names of bidders, &c.
2. Abstract of contracts for each work, with names of contractors.
3 and 4. Copy of notice inviting proposals for removing sunken rocks.

GEORGE THOM,
Lieut. Colonel of Engineers, Bvt. Brig. Gen. U. S. A.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, July 1, 1868.

No. 1.

Abstract of bids received for the improvement of Saco river, Maine.

Nature of work.	Number for reference.	Names of bidders.	Amount bid for.	Price.
For removing sunken rock.....	1....	Jas. M. Andrews, Biddeford. Maine.	Whole work.	$2,000
*For removing sunken rock	2....	* Reuben Wiley, Seabrook, N. H.	Whole work.	200

* Contract for this work was not signed until July 10, 1868.

GEO. THOM,
Lieutenant Colonel of Engineers, Brevet Brigadier General U. S. A.

No. 2.

Abstract of contracts made for the improvement of Saco river, Maine.

Nature of work.	Number for reference.	Name of contractor.	Quantity.	Price.
For removing sunken rock.....	1....	Jas. M. Andrews, Biddeford, Maine.	Whole work.	$2,000

GEO. THOM,
Lieutenant Colonel of Engineers, Brevet Brigadier General U. S. A.

Each proposal must be accompanied by a written guarantee, si
two responsible persons, in the required form, and the bidder wil
called, if his proposal is accepted, enter into a contract and bon
good and sufficient security, for the true and faithful performanc
contract. The contract will be awarded to the lowest responsi
der, and be subject to the approval of the Secretary of War.

The undersigned, however, reserves the right to exclude the
any person who there is reason to believe will not faithfu
promptly perform the contract; also any informal bids, as well a
that are above a reasonable price for the work; and no member
gress, officer or agent of the government, nor any person empl
the public service, shall be admitted to any share in the contract
benefit which may arise therefrom.

Payment will be made on the satisfactory completion of the w

Persons desiring to make proposals will please call on the
signed at his office, in Morton Block, on Congress street, for f
same and for definite information, if desired; and on transmittin
will indorse thereon, "Proposals for removing rock in Saco river,

GEORGE THOM
Brevet Brigadier General U. S. A

UNITED STATES ENGINEER OFFICE,
Portland, Maine, September 16, 1867.

No. 4.

Proposals for removing a sunken rock in Saco river, Maine.

Proposals will be received at this office until 3 o'clock p. m. o
day, the 22d instant, for removing a sunken rock in mid-channel
river, near Little islands. The rock has an irregular shape, av
about 20 feet long, by 12 feet wide, and two and a half feet in
The depth of water at this place is from seven to eight feet at me

called on, if his proposal be accepted, enter into a contract and bond, with good and sufficient security, for the true and faithful performance of his contract. The contract will be awarded to the lowest responsible bidder, and be subject to the approval of the Secretary of War.

The undersigned, however, reserves the right to exclude the bids of any persons who there is reason to believe will not faithfully and promptly perform the contract; also any informal bids, as well as those that are above a reasonable price for the work; and no member of Congress, officer or agent of the government, nor any person employed in the public service, shall be admitted to any share in the contract, or any benefit which may arise therefrom.

Payment will be made on the satisfactory completion of the work.

Persons desiring to make proposals will please call on the undersigned, at his office in Morton Block, Congress street, for forms of same, and for more definite information, if desired; and on transmitting them will indorse thereon, "Proposals for removing rock in Saco river, Maine."

GEORGE THOM,
Brevet Brigadier General U. S. Army.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, July 12, 1867.

T 1.

II.—*Report on the extension of the breakwater in Portland harbor, Maine, for the year ending June* 30, 1868, *by Brevet Brigadier General George Thom, lieutenant colonel of engineers.*

By an act of Congress approved June 23, 1866, an appropriation was made for this work amounting to $105,111 05, being the amount that was estimated for the entire completion of the work on the original plan.

A board of engineers, in June, 1867, recommended a modification of the original plan, requiring for its construction a less amount than that appropriated. Before determining upon any plan, however, it was deemed necessary by the department to make a full series of current and tidal observations at such points in the harbor as might be found useful in arriving at proper conclusions. These observations were made by Mr. A. Grant Childs, assistant engineer, and finished in August, 1867; my report on which, with accompanying maps and diagrams, were submitted to the department on the 19th of September, 1867, with the approval of the department. I also had, with the co-operation of the superintendent of the United States Coast Survey, a very minute hydrographic survey of the harbor, made in October and November last, the report on which, with a chart of the survey on a scale of $\frac{1}{3000}$, were transmitted to the department in April and May last.

The plan for the extension of this work not having been determined on, operations have been confined during the past year to the completion of the unfinished capping of the present work. In obedience to instructions from the department, I advertised for proposals for this capping, (see copy of advertisement herewith, marked 1,) and entered into contracts with the three parties who were the lowest bidders for the three kinds of work and materials to be furnished, to wit: August 9, 1867, with Messrs. Peirce & Rowe, of Frankfort Mills, Maine, for furnishing the stone; August 6, 1867, with Mr. George P. Wescott, of

Portland, Maine, for performing the labor; and August 6, 1867, with Messrs. Charles Staples & Son, of Portland, Maine, for furnishing the composition bolts; (see papers hereto appended, marked 2 and 3.) Operations under these contracts were commenced on the 1st of September, 1867, and at the close of the present fiscal year, 538 lineal feet of the capping was finished, leaving but 195 lineal feet at its outer extremity to be done under the contract.*

By a joint resolution of Congress, approved June 5, 1868, it was resolved "That so much of the unexpended balance of the appropriation for the breakwater in Portland harbor, Maine, as the chief engineer shall deem proper, may be expended under his direction in excavating the middle ground near said breakwater and in otherwise protecting the channel from injury by filling and improving the same."

In compliance with instructions from the department, dated June 22, 1868, (a copy of which is hereto appended, March 4,) I submit my views on the subject of improving the harbor, as called for by the joint resolution, (a copy of the same being hereto appended, marked 5,) which received the approval of the department.†

The amount appropriated for this work is deemed sufficient for the breakwater as well as for the proposed harbor improvements, and it is probable that the work will be completed during the fiscal year ending June 30, 1869.

Available balance of appropriation, June 30, 1867.....	$102,519 91
Amount of expenditure (including the retained percentage) during the fiscal year ending June 30, 1868.....	23,122 04
Amount available June 30, 1868.....	79,397 87

This work is situated in Portland harbor, Maine, there being a light-house on the outer extremity of the breakwater, and another at the entrance to the outer harbor. Fort Georges, Preble, and Scammell are all in the immediate vicinity of the work.

The amount of revenue collected for the fiscal year ending June 30, 1868, as stated by the United States collector of customs, is as follows, viz:

Duties on imports.....	$787,213 96
Hospital and tonnage duties.....	25,295 94
Total.....	812,509 90

The amount of duties assessed at this port for the same period, which includes, in addition to the foregoing, duties on goods in transit to the British provinces, and on those transported to other domestic ports in bond, is $8,399,702 64. The amount of commerce and navigation that would be benefited by the completion of this work is as follows, viz: The number of foreign entrances and clearances at this port for the year ending June 30, 1868, was 1,153; the number of domestic entrances and clearances for the same period was 1,320. This statement exhibits but a part of the commerce that would be benefited by the work, as a very large number of vessels put into this harbor during the year without making entry at Portland.

* This was completed on the 20th of August, 1868.

† A contract was made July 23, 1868, with Messrs. A. B. Cooley & Co., of Philadelphia, for completing this work in November, 1868, and operations were commenced on the 13th of August.

The improvements now in progress on the breakwater may be egarded as permanent, and such as after completion will not require urther expenditure. The dredging may have to be repeated to some xtent at some future time, but when and to what extent cannot now be oreseen.

The papers described as follows are hereto appended:

1. Copy of notice inviting proposals for breakwater.
2. Abstract of proposals, with names of bidders, &c.
3. Abstract of contracts for each work, with names of contractors.
4. Copy of instructions from chief engineer.
5. Copy of plan proposed for improving harbor, in furtherance of oint resolution of Congress.

GEO. THOM,
Lieutenant Colonel of Engineers, Bvt. Brig. Genl. U. S. A.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, July 1, 1868.

No. 1.

Proposals for completing the unfinished capping of the present breakwater in Portland harbor, Maine.

Proposals will be received at this office, until 2 o'clock p. m., on Saturlay, the 20th instant, for completing the above-named work in conformty with the plans in this office. To complete the capping, the following lescribed work will require to be done, viz:

1. Six hundred and thirty-two lineal feet of granite capping, 10 feet n width, which is to be laid in two courses, each having a rise of two eet three inches. The lower course to be composed of stones not less han eight feet in length, to be laid longitudinally in three rows, and the ntervals between to be filled with rubble stone; and the upper course of stones 10 feet in length and not less than two feet in width, to be aid transversely.

2. One hundred lineal feet of granite capping, nine and a half feet in vidth, on the shore end of the breakwater, which also must be laid in two courses, each having a rise of two feet two inches; the lower course to be composed of stones not less than eight feet in length, to be laid longitulinally in three rows, and the intervals between to be filled with rubble tone; and the upper course of stones, nine feet six inches long and not ess than two feet wide, to be laid transversely.

3. Rubble stone in addition to the above to be furnished and laid in position, wherever required to level up for the capping in conformity vith the plans, not exceeding 75 cubic yards.

The work must be commenced immediately after the delivery of the approved contract, and be completed on or before the 1st of July, 1868; with the understanding that not less than 500 lineal feet of the required capping will be finished on or before the 15th of December next.

Each proposal must be accompanied by a written guarantee, signed by two responsible persons, in the required form, that the bidder will, when called on, if his proposal be accepted, enter into a contract and bond, with good and sufficient security, (the sureties and their places of resilence to be named in the proposal,) for the true and faithful performance of his contract. The contract will be awarded to the lowest responsible bidder, and be subject to the approval of the Secretary of War.

The undersigned, however, reserves the right to exclude the bids of persons who there is reason to believe will not faithfully and prom perform the contract; also, any informal bids, as well as those tha above a reasonable price for the work, and no member of Cong officer or agent of the government, nor any persons employed in public service, shall be admitted to any share in the contract, or benefit which may arise therefrom.

Payments will be made *pro rata* for the work done, in three in ments; the first, on the completion of 300 lineal feet of the work second, at the end of the season's operations; and the third, on the factory completion of the whole work contracted for—20 per cent. reserved from each payment until the whole work is finished, and forfeited in the event of the non-fulfillment of the contract in the and manner as therein required.

Persons desiring to make proposals will please call on the undersi at his office in Morton Block, on Congress street, for forms of same for more definite information, if desired; and, on transmitting them indorse thereon "Proposals for Portland breakwater, Me."

GEO. THOM,
Bvt. Brig. Gen. U. S.

No. 2.

Abstract of bids received for extending the breakwater, Portland ha Maine, applied to completing the unfinished capping.

Nature of work.	No. for reference.	Name of bidder.	Amount bid for.	Price.
For furnishing all the granite.	1	Isaac Hamilton, Cumberland. Maine.	Whole work.	$25 per running breakwater comp
For furnishing all the granite.	2	George P. Wescott, Portland, Maine.	Whole work.	$25 per running breakwater comp
For furnishing all the granite.	3	Geo. A. Peirce & John S. Rowe, Frankfort, Me.	Whole work.	$24 45 per runn breakwater comp
For furnishing composition bolts.	1	Charles Staples & Son, Portland, Maine.	Whole work	39 cents per pou
For labor	1	Isaac Hamilton, Cumberland, Maine.	Whole work.	$12 per lineal fo
For labor	2	George P. Wescott, Portland, Maine.	Whole work.	$11 per lineal fo

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S.

No. 3.

Abstract of contracts made for extending the breakwater, Portland harbor, Maine, applied to completing the unfinished capping.

Nature of work.	No. for reference.	Name of contractor.	Quantity.	Price.
For furnishing all the granite.	1	Peirce & Rowe, Frankfort, Maine.....	Whole work..	$24 45 per running foot of breakwater completed.
Furnishing composition bolts.	2	Charles Staples & Son, Portland, Maine.	750 pounds, (more or less.)	39 cents per pound.
For labor	3	George P. Wescott, Portland, Maine.	Whole work..	$11 per lineal foot.

GEO THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A.

No. 4.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., June 22, 1868.

GENERAL: A copy of a joint resolution of Congress, of June 5, 1868, in relation to the breakwater at Portland, Maine, is herewith inclosed.

You will please submit your views upon the subject referred to, together with estimates for such excavation as may be deemed necessary upon the middle ground near the breakwater, showing the position, width, and depth of such channel as you may propose, its probable cost, and what balance from the appropriation for the extension of the breakwater will be available for this purpose, and "for otherwise protecting the channel from injury by filling and for improving the same."

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. Commanding.

Lieut. Col. and Bvt. Brig. Gen. GEO. THOM,
Corps of Engineers, Portland, Maine.

PUBLIC RESOLUTION—No. 25.

JOINT RESOLUTION in relation to the breakwater at Portland, Maine.

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That so much of the unexpended balance of the appropriation for the breakwater in Portland harbor, Maine, as the chief engineer shall deem proper, may be expended under his direction in excavating the "middle ground" near said breakwater, and in otherwise protecting the channel from injury by filling and improving the same.

Approved June 5, 1868.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, June 30, 1868.

GENERAL: In compliance with instructions of the 22d instant, I have the honor to herein submit my views upon the subject of "excavating

the middle ground near said (Portland) breakwater, and otherwise protecting the channel from injury by filling and improving the same," in furtherance of the joint resolution of Congress approved June 5, 1868, a copy of which accompanies your instructions; together with estimates of the probable cost of same, and what balance from the appropriation for the extension of the breakwater will be available for this purpose.

1st. For the completion of the capping of the breakwater under existing contracts, including outstanding indebtedness on same account, there will be required	$19,531
For completing breakwater on plan recommended by board of engineers	35,000
Contingencies	5,453
Total	59,984
Unexpended balance of appropriation this date	91,931
Amount available for improving harbor, in pursuance of joint resolution approved June 30, 1868	31,947

Or (say) $30,000.

The joint resolution authorizes the excavation of the "middle ground," but it doubtless was intended to apply to the "bar" at the entrance to the river harbor, lying between the "middle ground" and the outer end of the breakwater. This bar, or that portion of it nearest the Portland shore, may properly be considered as forming a part of the "middle ground," and this is where the interests of commerce require the excavation to be made. Borings recently made on this "middle ground" and bar show that the middle ground is composed of soft mud to a depth of 13½ feet, (or 25 feet below mean low water,) below which borings were continued two feet further, through sand or gravel, without finding any ledge or other obstruction, to a depth of 27 feet below mean low water; that the "bar" is composed of soft mud to a depth of six or seven feet, (or 22 to 23 feet below mean low water,) below which borings were continued to a depth of from one to three and one-half feet, through sand or gravel, without finding any ledge or other obstruction, to a depth of 23½ to 26½ feet below mean low water. These facts show that there will be no difficulty in excavating a channel to the desired depth.

The accompanying sketch exhibits the location and extent of the channel which I would recommend to be excavated. It is located on the southern slope of the "middle ground," through the deepest water, and so as to conform to the set of the tidal currents. The general width of the proposed channel is 300 feet, which is sufficient for two vessels to pass each other, and is opened at each end, so as to receive flood and ebb currents, and to enable vessels to take any desired course, whether inward or outward bound.

The depth of excavation should not be less than 19 feet, nor is it desirable to have it more than 20 feet below mean low water; and I would suggest that these limits be adopted, and that the depth should depend upon the prices at which contractors will undertake the work.

In an interview with the harbor commissioners of this city, I explained to them my views concerning this matter, and they entirely concur in them as being adapted in every way to meet the present wants of the commerce of this harbor. They, however, express a wish that, for the pupose of affording increased facilities to the ocean steamers, which are deemed of much importance to this place, the lower end of the bar off

Grand Trunk wharves should also be removed, so that those steamers
- have easy access to those wharves. For the reasons stated, I also
ommend that this be done.
he following estimates are submitted for these improvements, viz:

For excavating a channel through the southern slope of ıe "middle ground" to a depth of 17 feet below mean low ater, requiring 36,000 cubic yards, at 40 cents.....	$14,400
avating the bar off Grand Trunk wharves, 3,300 cubic ards, at 40 cents.....	1,320
	15,720
ling 10 per cent. for contingencies.....	1,572
Total.....	17,292
For a channel 20 feet in depth at mean low water through ıe middle ground bar, 60,000 cubic yards, at 40 cents.....	24,000
noving Grand Trunk bar, 5,000 cubic yards, at 40 cents....	2,000
	26,000
l 10 per cent. for contingencies.....	2,600
	28,600

'rom which it is seen that it is probable that the amount of appropria-
ı available for this work will admit of the excavation of the channel
, depth of 20 feet. This will depend upon the price for which con-
:tors will undertake it; I do not think, however, it will cost more
n 40 cents per cubic yard.
would not recommend in connection with this matter any other work
r protecting the channel from injury by filling and for improving
ıe."

Very respectfully, your obedient servant,

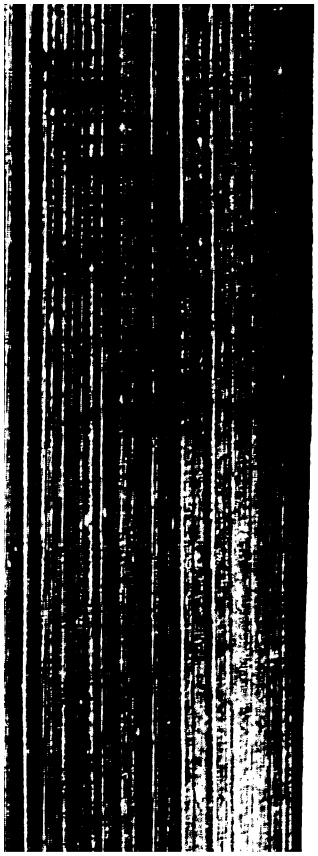
GEORGE THOM,
Lieut. Col. of Engineers, Brevet Brig. Gen. U. S. A.

[ajor General A. A. HUMPHREYS,
Chief of Engineers U. S. A., Headquarters
Corps of Engineers, Washington, D. C.

T 2.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., December 4, 1867.

ENERAL: Regarding the communication of Mr. Farmer, of Portland,
ine, upon the harbor and breakwater, &c., I desire to state that the
ndings and shore lines he refers to as just completed by a Coast Sur-
party have been made under the direction of Brevet Brigadier Gen-
l Thom, corps of engineers, as the concluding portions of an investi-
ion upon the currents, tides, depths of water in the channel and on
shoals, and changes in the physical condition generally of the harbor
Portland, entered into and carried on by instructions from these head-



water already built. He was directed not to extend it, a decisio that point having been reserved until the investigations set on fo completed.

A copy of the letter of Mr. Farmer has been transmitted to (Thom with directions to comply with the indorsement of the Se of War.

Very respectfully, your obedient servant,

A. A. HUMPHREYS
Brigadier General Comma

General U. S. GRANT,
Secretary of War ad interim.

T 3.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 4,

GENERAL: Referring to the letter from these headquarters of December, 1867, in relation to changes stated by Mr. J. L. Farme letter to the Hon. W. P. Fessenden, to have taken place in the of Portland, Maine, I beg leave to state that the subject was refe Brevet Brigadier General George Thom, lieutenant colonel of eng who reports, as the result of examinations recently made under his tion, that the water has *increased* in depth on the "middle grou well as in the channel between it and the breakwater, and that th of the "middle ground" is now less than is shown on the Coast S charts of 1853–'62.

In regard to the grounding of the steamer Moravian, referred to letter of Mr. Farmer, General Thom reports that it took place at lo and according to the tide tables the depth at the time was abo inches lower than at mean low water. The steamer was not in the

T 4.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., June 22, 1868.

GENERAL: A copy of a joint resolution of Congress of June 5, 1868, in relation to the breakwater at Portland, Maine, is herewith inclosed. You will please submit your views upon the subject referred to, together with estimates for such excavation as may be deemed necessary upon the Middle Ground near the breakwater, showing the position, width and depth of such channel as you may propose, its probable cost, and what balance from the appropriation for the extension of the breakwater will be available for this purpose, and "for otherwise protecting the channel from injury by filling and improving the same."

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Leiut. Col. and Brevet Brig. Gen. GEO. THOM,
Corps of Engineers, Portland. Maine.

PUBLIC RESOLUTION—No. 25.

JOINT RESOLUTION in relation to the breakwater at Portland, Maine.

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That so much of the unexpended balance of the appropriation for the breakwater in the harbor of Portland, Maine, as the Chief Engineer shall deem proper, may be expended under his direction in excavating the "Middle Ground" near said breakwater, and in otherwise protecting the channel from injury by filling and improving the same.

Approved, June 5, 1868.

T 5.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., July 2, 1868.

GENERAL: Your letter of June 30, relating to the improvement of the harbor of Portland, Maine, by dredging in the Middle Ground or bar near the breakwater in furtherance of the joint resolution of Congress approved June 5, 1868, has been received, and the views therein set forth are concurred in.

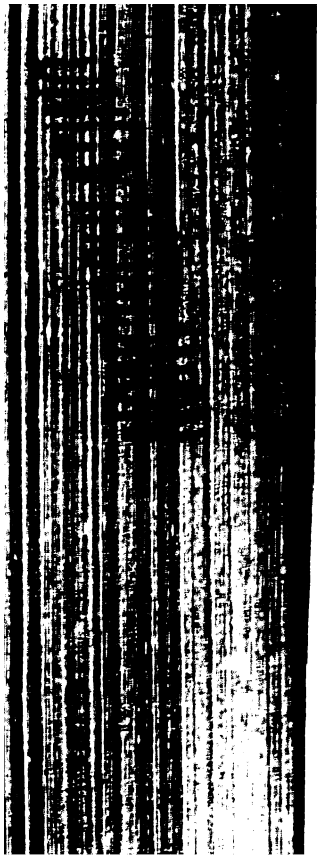
The location and extent of the dredging recommended by you as indicated in the sketch accompanying your letter is approved, and you will please take steps for carrying the work into execution by contract, as required by the act making the appropriation. The general width of the channel, 300 feet, seems to be ample, but the excavation should be carried on to such a depth as will give 20 feet at mean low water.

By command of Brigadier General Humphreys.

Very respectfully, your obedient servant,

JNO. G. PARKE,
Maj. of Engineers, Brevet Maj. General U. S. A.

Brevet Brigadier General GEORGE THOM,
Lieut. Col. of Engineers, Portland, Maine.



the depth to be seven feet up to Hallowell bridge, and six feet to Augusta, in the lowest stages of the river, a greater depth not practicable above Hallowell owing to the ledge met with on the

In order to render this channel safely navigable for the large of side-wheel steamers which run on the river below, the width in my opinion, be increased to 100 feet. Recent surveys show tha 180,000 cubic yards of dredging (measured in the scows) will b sary, which at 40 cents per cubic yard, (the present contract pr for the work,) will cost $7

Adding 10 per cent. for contingencies 7

Total 7

Or say for the completion of the work from Gardiner to Augusta $8

For that portion lying between Sheppard's Point and Augusta, the amount appropriated by acts of Congress, approved June 23, 1866, and March 2, 1867 5

Additional appropriations required 3

which it is estimated will be sufficient for completing the impro and can be profitably expended during the fiscal year ending J 1870.

The character of the bed of the river is such, that it is not p that any material change will occur in the channel when once p dredged.

Under a contract made May 23, 1867, with Mr. Augustus R. (as stated in my last annual report,) for dredging the new channel t Sheppard's Point shoal and Hallowell shoal, operations have be ried on during the year, though very much impeded by the un early closing of the river by ice in November, as well as by the dinary freshets late in the spring of 1868. During the year endi 30, 1868, 29,009 cubic yards have been removed by dredging fr new channel.*

Under authority of the department, dated the 10th of Januar

3.) The contractor expects to finish his contract to the extent that the available amount of appropriation will allow, in the time required.

Unexpended amount of appropriation, June 30, 1867.....	$49,770 15
Amount of expenditure (including retained percentage) during the fiscal year ending June 30, 1868.....	13,199 67
Available balance June 30, 1868.....	36,570 48

The following information called for by the act of Congress making appropriations for this work is supplied, viz: The improvements are located in the collection district of Bath, Maine, which is the only port of entry in this collection district, and is situated on the Kennebec river, about 30 miles below Hallowell. The United States arsenal is located at Augusta, on the left bank of the Kennebec, and Fort Popham is at the mouth of the river, about 40 miles below Hallowell. Seguin and Pond Island light-houses are near the mouth of this river.

The amount of revenue collected at Bath (the port of entry) for the fiscal year ending June 30, 1868, is $28,854 85. The amount of commerce and navigation that would be benefited by the completion of the proposed river improvement (as copied from my last annual report) is as follows, viz:

The whole tonnage of this district is something over 80,000 tons, all of which would be more or less benefited by the improvement of the navigation of the Kennebec. The works near the mouth of the river, such as Fort Popham, Seguin and Pond Island lights, are designed for the benefit of the whole district.

The improvements proposed between Augusta and Gardiner would more particularly benefit vessels bound to and leaving those ports, and the completion of the work doubtless cause great increase of business at those points.

One steamboat has plied between Hallowell and Boston, and one between Gardiner and Boston during the past season, carrying many passengers and much freight. These steamers would extend their trips to Augusta if the contemplated improvement is made.

The arrivals at Hallowell and Augusta in 1865 were 42 coastwise and five foreign vessels.

At Gardiner, four miles below Sheppard's Point, the arrivals were 223 coastwise and 10 foreign vessels.

During the past year this trade has somewhat increased.

The following described papers are appended hereto, to wit:

1. Abstract of proposals.
2. Abstract of contracts.
3. Copy of notice inviting proposals for dredging.

GEORGE THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, July 1, 1868.

No. 1.

Abstract of proposals received for the improvement of Kennebec river, Mai

Nature of work.	No. for reference.	Names of bidders.	Amount bid for.	Price per cubic
			Cubic yards.	
Dredging a new channel through Britt's shoal and Gage's shoal between Hallowell and Augusta, Maine.	1	A. B. Cooley & Co., Philadelphia, Penn.	45,000 (more or less.)	$0
	2	Jonas H. Perley, Portland, Maine.	45,000 (more or less.)	
	3	Augustus R. Wright, Geneva, New York.	45,000 (more or less.)	

GEORGE THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A

No. 2.

Abstract of contracts made for improvement of Kennebec river, Maine

Nature of work.	No. for reference.	Name of contractor.	Quantity.	Price per cubic
			Cubic yards.	
Dredging a new channel through Britt's shoals and Gage's shoal, between Hallowell and Augusta, Maine.	1	Augustus R. Wright, Geneva, New York.	45,000 (more or less)	$0

GEORGE THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A

No. 3.

Proposals will be received at this office until 3 o'clock p. m., Wednesday, the 20th instant, for dredging a new channel in Kennebec river, through Britt's shoal and Gage's shoal, between Hallowell a Augusta, Maine, requiring 45,000 cubic yards, more or less, of dredgi The channel will be excavated, first through Britt's shoal, and then upward toward Augusta; and the material excavated will be deposit in such places and in such manner, in the river, as may be required the engineer in charge.

Bidders will state the price per *cubic yard*, to be *measured in the scows*, which will also include the depositing of the material as required. The work must be commenced as soon as practicable after the approval of the contract, and be completed not later than the 20th of November next.

Payments will be made monthly, 20 per cent. to be reserved therefrom until the whole work is satisfactorily completed, and be forfeited in the event of the non-fulfillment of the contract in the time and manner required.

The undersigned reserves the right to reject the bid of any person who, there is reason to believe, will not faithfully and promptly perform the contract, as well as all informal and unreasonable bids.

Persons desiring to make proposals will please call on the undersigned, at his office in Morton block, in Congress street, for forms of same, and for more definite information as to the conditions imposed on bidders and contractors, if desired; and on transmitting their bids will indorse thereon "Proposals for dredging Kennebec river."

GEORGE THOM,
Lieutenant Col. of Engineers, Bvt. Brig. Gen. U. S. A.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, January 15, 1868.

T 7.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 10, 1868.

GENERAL: Your letter of the 7th instant is received. Your views concerning the improvement of the Kennebec river are concurred in by these headquarters, and your recommendation that a depth of six feet be adopted for the channel above Hallowell, and also your proposed plan of improvement, viz., "by dredging a new channel through Britt's shoal and Gage's shoal, having a width of 75 feet on its bottom and a depth of six feet in the lowest stages of the river," are approved.

You are authorized to advertise for proposals for the dredging required, the measurement to be made in the scows, &c.

By command of Brigadier General Humphreys.

Very respectfully, your obedient servant,

J. C. WOODRUFF,
Lieut. Colonel of Engineers, Bvt. Brig. Gen. U. S. A.

Brevet Brig. Gen. GEORGE THOM,
Lieutenant Colonel of Engineers, Portland, Me.

T 8.

IV.—*Report on the improvement of the navigation of St. Croix river above the ledge, for the year ending June* 30, 1868, *by Brevet Brigadier General George Thom, lieutenant colonel of engineers.*

By an act of Congress approved March 2, 1867, the sum of $15,000 was appropriated for the improvement of this river, "Provided, the province of New Brunswick shall contribute and pay to the proper disbursing officer a like sum for said purpose; said payment being made on condition that in no event shall the province of New Brunswick be called upon for more than one-half the sum actually expended for said purpose."

Total	99,(
Deducting one-half if paid by the province of New Brunswick	49,
	49,
Amount appropriated by act of Congress approved March 2, 1867	15,
	34,

Additional amount required, say, $35,000, which amount co profitably expended upon the work during the fiscal year ending 30, 1870.

The following information is supplied in compliance with the r ments of the act of Congress making an appropriation for this wo

The contemplated improvements of the St. Croix river above th are within the collection district of Passamaquoddy, and near t tom-house in Calais. There is no United States light-house now near this place, the nearest being in the vicinity of Eastport, about 30 miles below. There is no fort in the immediate vicinit Sullivan, also at Eastport, being the nearest.

The amount of duties collected at the custom-house in Calais, fiscal year ending June 30, 1868, was $23,387 30.

The amount of commerce and navigation that would be benef these improvements, consist of about 1,000 vessels, probably ave about 100 tons each, which arrive at this port annually, being pally engaged in the coasting trade.

GEORGE THOM,
Lieut. Col. of Engineers, Brevet Brig. Gen. U.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, July 1, 1868.

December, it extended only so far as to enable me to form an approximate estimate of the nature and extent of the operations required for the improvement of the river between Shepard's Point and Augusta, Maine, for which an appropriation had been made under the same act of Congress. During the past year this survey was resumed and completed from Gardiner up to Augusta, thereby furnishing very reliable data for an estimate of the work of improvement between those points.

The improvement of this river consists in straightening and deepening the channel by dredging through the several shoals which obstruct its navigation. This new channel is being dredged between Shepard's Point and Augusta, to a width of 75 feet on its bottom, with sides having a slope of two feet to one foot rise, and seven feet in depth up as far as Hallowell bridge, and thence to Augusta bridge six feet in depth in the lowest stages of the river, a greater depth not being practicable owing to the ledge met with on the shoal above Hallowell. But in my opinion the width of this channel should be increased to 100 feet, so as to render it safely navigable for side-wheel steamers of the largest class, now running on the river below.

The more recent survey shows that for a channel of this width, from Gardiner to Augusta, will require about 180,000 cubic yards of dredging, (measured in scows,) which, at 40 cents per cubic yard, (the present contract price for the work,) would amount to..... $72,000 00
Adding 10 per cent. for contingencies..... 7,200 00

79,200 00

Say..... 80,000 00
By acts of Congress approved June 23, 1866, and March 2, 1867, there has been appropriated for a portion of this work lying between Shepard's Point and Augusta the sum of... 50,000 00

So that the additional amount of..... 30,000 00
will be required for its completion.

Accompanying this are six sheets showing the results of the hydrographic survey of this river. Five of them, on a scale of $\frac{1}{2000}$, show the river and proposed channel in sections, and the other sheet, on a scale of $\frac{1}{10000}$, shows the same entire.

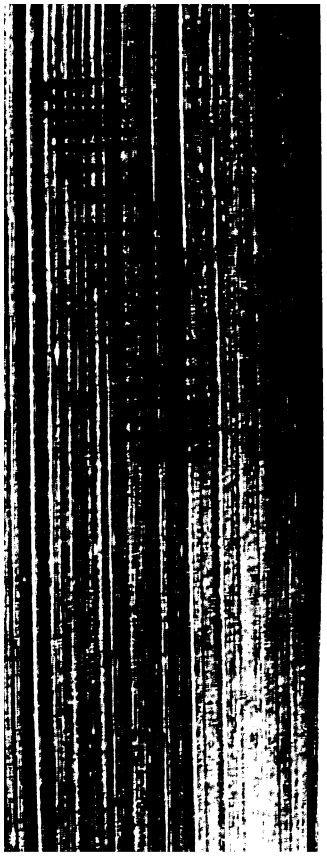
The following information, called for by the act of Congress providing for this survey, is supplied, viz:

The improvements are located in the collection district of Bath, Maine, which is the only port of entry in this collection district, and is situated on the Kennebec river, about 30 miles below Hallowell. The United States arsenal is located at Augusta, on the left branch of the Kennebec, and Fort Popham is at the mouth of the river, about 40 miles below Hallowell. Seguin and Pond Island light-houses are near the mouth of this river.

The amount of revenue collected at Bath (the port of entry) for the fiscal year ending June 30, 1868, is $28,854 85.

The amount of commerce and navigation that would be benefited by the completion of the proposed river improvements (as copied from my last annual report) is as follows, viz:

The whole tonnage of this district is something over 80,000 tons, all of which would be more or less benefited by the improvement of the navigation of the Kennebec. The works near the mouth of the



somewhat increased.

GEORGE THOM,
Lieut. Col. of Engineers, Bvt. Brig. General U. S.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, July 1, 1868.

T 10.

Report on the survey of Penobscot river above Hampden, Maine, wit
posed plan for the improvement of its navigation and an estimate
cost, by Brevet Brigadier General George Thom, Lieutenant Colo
Engineers.

The survey of Penobscot river above Hampden, Maine, ordered
"An act, approved June 23, 1866, making appropriations for the re
preservation, and completion of certain public works," &c., was p
in my charge in November, 1866, too late in the season to comm
work upon it.

By an arrangement made in April last with Professor Peirce, s
intendent of the United States Coast Survey, a surveying part
assigned by him to this work, under the charge of Mr. James A.
van, sub-assistant United States Coast Survey, with instructio
report to me for such surveys and observations as I should ind
On the 29th of June, when Mr. Sullivan reported to me, I gave him
instructions as I thought necessary (see Appendix T 11) to ascertai
nature, extent, and cause of the existing obstructions to the navig
of the river between Hampden and Bangor, "and to procure the
mation necessary to make an estimate of the cost of the removal
prevention of those obstructions." Additional instructions were s
quently given to him as occasions arose during the progress o
survey.

gent laws, the navigation of this river will, at no distant day, be entirely obstructed above Hampden, and probably still lower down. At present these obstructions lie principally between Seven Pine Point (a short distance above Crosby's Narrows) and Independence Rock, in the harbor of Bangor—a distance of three and one-half miles; covering an area of about 320 acres to an average depth of 10 feet, being, in some locations, more than 18 feet in depth. These deposits form an entangled mass, the solid contents of which exceed 5,000,000 cubic yards. The depth of these deposits has been ascertained by numerous borings, carefully made with iron rods.

From all these examinations it has been ascertained that the river, instead of having, as formerly, a wide, clear, and unobstructed channel of three fathoms in depth, at low water, all the way up to Bangor, has now a narrow, tortuous, and uncertain channel, with but eight or nine feet of water, at lowest water. The *lowest* water, in dry seasons, it is stated, is about three feet lower than the mean low water observed during the survey. The ordinary rise and fall of the tide at Bangor is from 12½ to 13 feet, approximately.

There are also obstructions in the Penobscot below Hampden, in the vicinity of Winterport, at Indian Point, above Bucksport, and at Orphan's island, where bars, composed more or less of sawdust, are said to be forming and rapidly increasing. In addition to these obstructions, there are several rocks in the harbor of Bangor, which are very dangerous to navigation, the most important of which are:

1. Independence Rock, below and near the lower end of the planing-mill wharf. This rock appears to be a continuation of the ledge at the steamboat wharf. It projects about six feet (on an average) above its general base, for a length of about fifty feet, the highest point having less than two feet of water upon it in the lowest stages of the river, there having been but four feet upon it at mean low water during the survey.

2. The ledge at the steamboat wharf. This is about 30 feet long, with an average depth on its top of about five feet below the *mean low water* observed during the survey; the highest point of the rock having not more than two feet of water upon it, in the *lowest* stages of the river.

3. Gulliver's Rock, abreast of steamboat wharf. This is apparently a boulder, containing about six cubic yards.

4. Ledge in the channel near Green's pier, and distant about 45 feet to the eastward of the pier. This ledge is about 15 feet long on its top, and has about eight feet of water upon it in the *lowest* stages of the river.

All these ledges have been examined and surveyed, with the aid of a submarine party, and their dimensions and positions have been carefully determined. In addition to these, there are several boulders scattered over the bed of the river.

The importance of this river and the harbor of Bangor (which is at the head of its navigation) can well be understood on referring to the accompanying letter from Hon. John H. Rice, collector of customs at Bangor, Maine, (see Appendix T 8,) in which he furnishes valuable and reliable statistics concerning its commerce. The benefit that would be derived from the improvement of its navigation would be almost incalculable could it be restored to its original condition. This, however, would involve the expenditure of millions, which it would not be advisable to do. Nor would it be advisable to undertake its improvement to any extent whatever unless the general government, by suitable and stringent legislation, can and will protect its navigable waters from

injury and ruin. The same cause which has produced the vast depos in Penobscot river is still in operation, and continues to increase th deposits; and so it is with nearly all the navigable rivers in Maine. It therefore, urgently and respectfully recommended that this matter brought to the attention of Congress at an early day, with a view securing such legislation as will hereafter effectually protect the n gation of all its navigable waters.

Any plan to be considered for improving the navigation of this r must embrace, first, the removal of the deposits above Hampden, s to open a new channel of sufficient capacity for navigation; and sec the removal of the sunken rocks in the harbor of Bangor.

The depth of this channel must be confined within two limits, the greatest desired depth of water which can be had up to Ba (*i. e.*, three fathoms in the lowest stages,) and two fathoms, which is more than is required for the ordinary commerce of the river. width of the channel should not be less than 150 feet, which woul no more than sufficient to enable two vessels of ordinary size to each other.

The following estimates are submitted for channels 12 and 18 in depth, in the *lowest* stages of the water, and 150 feet in width tween Seven Pine Point and Bangor, (a distance of 3½ miles,) viz:

1.—12 FEET CHANNEL.

For excavating 100,000 cubic yards slabs, edgings, and sawdust, (to be deposited 20 miles below) at $1 per cubic yard	$100,00
For excavating Independence Rock to its base 12 feet below low water, 212 cubic yards, at $35 per cubic yard	7,42
For excavating ledge at steamboat wharf, to its base, a depth of 12 feet below the *lowest* water, 80 cubic yards, at $35 per cubic yard	2,80
For removing Gulliver's Rock, 6 cubic yards, at $35 per cubic yard	21
For excavating ledge near Green's pier, to a depth of 12 feet below *lowest* water, 18 cubic yards, at $35 per cubic yard	63
	111,06
Add 10 per cent. for contingencies	11,10
Total	122,16

Or (say) $125,000.

2.—18 FEET CHANNEL.

For excavating 590,000 cubic yards slabs, edgings, and sawdust, (to be deposited 20 miles below,) at $1 per cubic yard	$590,00
For excavating Independence Rock, as above, 212 cubic yards, at $35 per cubic yard	7,42
For excavating ledge at steamboat wharf, as above, 80 cubic yards, at $35 per cubic yard	2,80
For removing Gulliver's Rock, 6 cubic yards, at $35 per cubic yard	21

For excavating ledge near Green's pier to a depth of 18 feet below the lowest water, 50 cubic yards, at $35 per cubic yard	$1,750 00
	602,180 00
Add 10 per cent. for contingencies	60,218 00
Total	662,398 00

Or (say) $665,000.

To effect a "permanent completion of the work" will be impossible, unless by some stringent and effectual legislation, on the part of the State or general government, the slabs, edgings, and sawdust are prevented from being thrown into the river from the saw-mills, which is still being done to the great injury of the navigation of the river.

Should an appropriation be made for this improvement, the sum of $75,000 could be profitably expended upon it during the next fiscal year.

The following additional information is furnished in compliance with the law of Congress providing for this survey.

It is in the collection district and port of Bangor, Maine.

Fort Knox (which is one of the largest forts in the United States) is being built for the protection of this river and the harbor of Bangor. It is located on its right bank, about 20 miles below Bangor.

At Fort Point, which is about six miles further down, at the mouth of the river, there is a government light-house.

The amount of revenue collected at Bangor during the fiscal year ending June 30, 1867, was $54,697 09.

As to the "amount of commerce and navigation that would be benefited by the completion" of the proposed work, I respectfully refer you to the letter of Hon. John H. Rice, United States collector of customs, at Bangor, (see Appendix C,) in which the requisite information is very fully stated.

GEORGE THOM,
Lieut. Col. Engineers, Bvt. Brig. General U. S. A.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, November 16, 1867.

T 11.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, June 29, 1867.

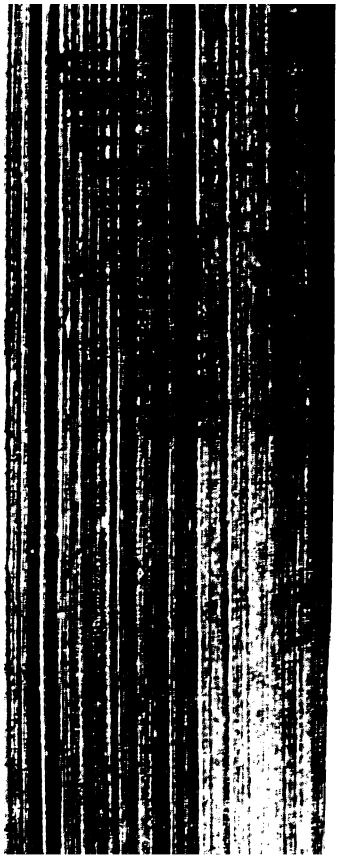
SIR: Having, as directed by the Superintendent of the United States Coast Survey, reported to me for instructions, for the survey of Penobscot river, Maine, under an arrangement made with the engineer department at Washington, you will please proceed with that work as soon as your arrangements are perfected therefor.

A law of Congress requires the Penobscot river to be surveyed above Hampden, Maine. The object of the survey is to ascertain the nature, extent, and cause of the existing obstructions to the navigation of the river between Hampden and Bangor, and to procure the information necessary to make an estimate of the cost of the removal and prevention of those obstructions.

These obstructions are reported to be of two kinds:

"1st. Rocks.

"2d. Bars which *are forming* across the river.



river, narrowing the channel and thereby rendering the navigati
cult, and threatening in time, unless arrested, to close the
altogether for the larger class of vessels. There are three of the
Going down the river, the first is just below the city of Bangor;
ond is at Hampden; the third is at Winterport.

"These bars are formed by slabs, edgings, and sawdust, which
the sediment carried down by the river, and cause its deposit.
come down the river from the saw-mills above Bangor, from O
and above, which, meeting the flood tide, are checked in their
collected in great masses in the eddies of the river, and finally sin
senting, where they can be seen, at low water, a tangled mass
material which will be difficult to remove.

"It may be observed that the saw-mills at Bangor do not inju
river. There is a market there for all their slabs and edgings f
wood, and the sawdust is shipped for packing ice or other pu
Such is not the case, however, above tide-water, where water-po
used for driving the mills, and where there is no market for firewo
no facilities for shipping the sawdust."

In making the survey of this river you will please connect i
such Coast Survey points as will make it available for future Coast S
purposes, so far as it goes.

The following memorandum will indicate to you the nature and
of the survey that is required for the purposes above named.

The shore lines to be run, and the soundings to be made in the
manner—all to be plotted on a scale of $\frac{1}{10000}$. Tide-gauges to be
lished at Hampden and Bangor; and observations to be made to
mine the times and heights of high and low water, for the purp
reducing the soundings in the river. Level lines to be run, conn
the two tide-gauges with the ordinary and freshet high and low
marks, and benches to be established for future reference.

Occasional borings to be made to determine the nature and ext
the deposits in the river bottom, where bars or other obstructions
and all rocks, sunken or exposed, lying in the channel or in an

T 12.

HALLOWELL, MAINE, *October* 31, 1867.

ERAL: In accordance with the letter of instructions of Professor
nin Peirce, LL. D., Superintendent United States Coast Survey,
June 19, informing me that the engineer department had "re-
d a survey of the Penobscot river from Hampden to Bangor, to
le with reference to plans and estimates for the improvement of
er," and directing me to report to you to make such surveys and
ations as you would indicate; and having learned through your
of instructions, dated June 29, the precise scope of the work;
s also directed by the Superintendent, having called upon the
or such data, projections, and instruments as would be required,
Portland for Hampden the evening of July 9, as soon as possible
eceiving the necessary data, &c., to make the survey desired.
l-work was commenced at Hampden in the afternoon, July 10.
ays occurred; the survey of the shore-line, wharves, and principal
of the river, from a point one and one-half mile below Hampden
g to the bridge at Bangor, was completed August 13.
able tidal observers having been stationed at Hampden and
r, simultaneous observations of tides commenced August 16, and
continued every 15 minutes, during the daytime only, as, there
a considerable freshet in the river, it was not considered neces-
o obtain, as a plane of reference for soundings, other than the
of high and low water during the days on which soundings
aken. This plane was subsequently referred to that of the lowest
nown in the river.
ndings were commenced August 20, and finished September 2,
ing the location of eight buoys as guides to subsequent examina-
f rocks and bars.
examination of bars by boring was commenced September 6, and
ued until the party was discharged, October 8; interrupted, how-
o assist in the submarine examination of rocks, September 11
.
ber 23 to October 31, inclusively, the examination by boring was
ued in localities in the vicinity of Hampden.
submarine examinations were made by the Messrs. Wiley, of Sea-
New Hampshire, employed by you for this purpose, in a very
ctory manner.
Wells Simpson, of Hampden, who was engaged by you as foreman
crew employed in examinations by boring, discharged his respon-
uties in a faithful and efficient manner. Whatever value will be
ed to the results of this part of the work is due to his skill and
.

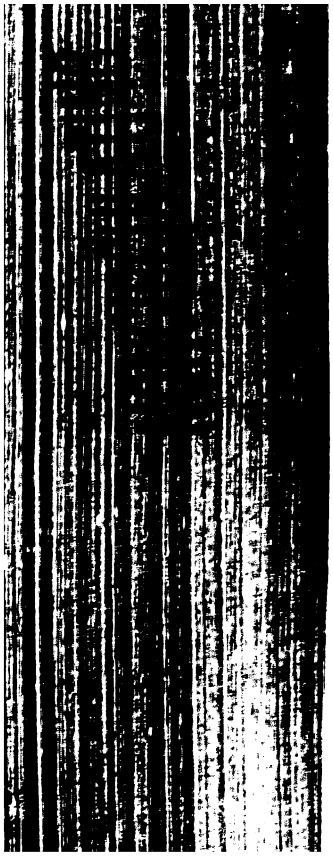
statistics of the survey are as follows, viz:

TOPOGRAPHY.

hores lines surveyed	17.6
wharves surveyed	6.7
oads surveyed	1.8
ences surveyed	6.0
f country as usually estimated, square miles	3.0

HYDROGRAPHY.

r of lines of soundings	224
r of soundings	3,779
er of points fixed by angles	132



of the river. The shore line and points determined for hydrogr purposes were transferred from the topographical sheet to this pre upon which the notes of soundings were plotted.

The larger circles in red mark the positions of the points dete by triangulation in 1863 and 1864 for the Coast Survey work vicinity. This survey is based upon these points. Thom station is one of the points of the primary triangulation, and pier is the position of the observatory for astronomical determ of latitude and longitude for the primary work.

The small circles in red upon the shore line mark the point mined for use in sounding; similar circles, in the channel of th the positions at which sextant angles were taken while soundin letters "a" to "g," and numbers by which they are designated, the note-books, to the particular day's work. Other circles of t color, distinguished by Roman numerals in red, show the positio buoys placed on bars and rocks.

The small circles in black are the points at which examinatio made by boring. The Roman numerals in black refer to the borings, where a description is found of the depth and characte deposits.

The dotted line in black within the shore line marks the curv plane of reference of the soundings. A reduction of three fe be made to reduce the depths given on this sheet to the plan lowest tides known.

The green, red, and blue lines denote, respectively, the 6, 12, feet curves.

The depths are given in feet within the 18-feet curve; wh depth is greater than 18 feet, it is given in fathoms and fract fathoms in feet.

The heavy blue [yellow] line, in pencil, marks the location o posed improvement of the navigation of the river; for conveni reference, in this report, attention is called to certain portions river by brackets in blue, in pencil, numbered I to VI.

You will observe, also, that above Crosby's Narrows the deeper
ter follows the western shore, which is bold and rocky, until, abreast
Stern's mill, it crosses the stream at nearly a right angle to its course;
nce, above Wiswell's wharf, it hugs the eastern shore, also bold and
ky, to the south point of the cove below South Brewer, where it crosses
stream diagonally to the bold, rocky point called Emery's Point.
reast of Edmonds's (now Blunt's and Hinman's) mill and Palmer's mill
deeper water disappears. For quite a distance the river is quite
al, the original channel being completely filled up by deposits. The
per water appears again at Severence's Point, on the eastern shore;
nce it crosses the stream diagonally to Low's ledge, above which it
in disappears.

From the bridge to Low's ledge there is at present a fall in the bed of
river of about six feet. It is probable that the original bed of the
er was not reached by the lead off the ledge, as, wherever the pres-
bed of the river has been examined, in the existing channel there
been found a deposit of sawdust varying in depth. As a depth of
feet was found a short distance below the bridge, upon the original
of the river, it is probable that the natural fall between these points
rom 9 to 12 feet.

t is inferred that there was once an average depth of water in the
er, from Snow's Point to Low's ledge, of about four and a half fathoms
ow mean low tide; that the shores were bold and the bed of the
er level, with a gravelly bottom, and the navigation unobstructed.
e old soundings give the same average depth between Orphan's
nd and the main land below Fort Knox.

The navigation of the river depends upon this body of water below
mean level of the sea. Displace it by obstructions, and the natural
ters of the river find their way to the sea, passing over or meandering
ough the deposits at low tide, without sufficient force to dislodge
m, and the river will become unnavigable excepting for the smaller
ss of vessels, and only at least at half tide.

t will be observed that the river is at least four-fifths filled with
tructions within the limits of the survey. These obstructions are of
kinds:

st. *Rocks.*—The rocks which obstruct the navigation of the river are
he harbor of Bangor.

ndependence Rock, the more important, is a projecting ledge of con-
erable extent. Numerous boulders are banked up around it, and
end, to a greater or less extent, to the ledge at the steamboat wharf,
ich appears to be a projection of the same strata. The steamboat
pany has *partially* removed the ledge at the wharf, since the survey
s made, to extend the wharf southward. Abreast of what is now the
th corner of the steamboat wharf, and 85 feet distant, is Gulliver's
k, which is apparently a boulder eight feet by four feet by five feet.
ty yards north of this is another small boulder. Around these ledges
boulders, in fact, everywhere upon the bed of the river, the divers
e up to their knees in sawdust, edgings, and fragments of slabs.

The last ledge examined was the ledge at Green's pier, which is to the
tward of the pier, and about 45 feet distant. It projects above a
ss of edgings and sawdust. It is in the present channel, and is dan-
ous.

n estimating for the removal of these obstructions, it must be borne
mind that an allowance of several feet must be made for the imbed-
portions of the ledges and boulders which could not be measured.
ns of these obstructions have been already placed in your hands.

remove. The depth of this deposit varies. Generally in the the river it averages ten feet. In some places, the bed of the r not reached at a depth of 18 feet below the surface of the bar.

Above Low's ledge, and in the center of the river, there ha been a gravel bar. There was, formerly, a sufficient channel three fathoms depth, on the eastern side of this bar. This east nel is now completely closed by a deposit of edgings, &c., abou deep. Underlying this gravel bar is found ledge. It is not im that the alluvial deposits from the united waters of the Kendusl Penobscot were made here, at the point where it appears from th ings that the natural fall in the bed of the river ceases, and wh in a sense may be called the estuary commences.

Before considering the cost of improvement of the navigati river, your attention is drawn to section VI, upon the chart, w will observe that the 18-feet curves nearly meet in the cent river, abreast of Bragden's Castle.

This is a good example of the process of formation of t Careful examination proves that there is at this point, across th bed of the river, six or seven feet of sawdust, the surface of comparatively free from alluvium, and upon which are frag edgings partially imbedded. On disturbing this sawdust, it the surface of the water at low tide, but settles away again i moments. It is not unlikely that the first freshet may depos cient quantity of alluvium upon it to pack together the looser p probably more recently deposited, into a solid mass. The frag edgings projecting above it, serve as barriers to arrest the pr others in their course as "tide walkers;" *i. e.*, the saturated about ready to sink is held perpendicularly in the stream, on few inches above the surface of the water. Such a "tide walke ing up or down stream with the current, or in an eddy, me obstruction below, is arrested, whirls around for a while, and th to add its quota to the deposit. It may require years for the upon a bar of this kind to reach so near the level of mean low t

rent is almost entirely on the surface. The practice of the fishermen is, to drop nets properly weighted, while the tide is still ebbing, through the outward surface current to the bed of the river, where they are violently expanded by the inward current of the flood tide.

The experiment has been tried, without success, of endeavoring to reach, in advance of the current, a hole at some distance above where the inward current has been perceived, by driving rapidly on the ice from one point to another. The effect of these currents upon the deposits in the river is readily suggested. It is not unreasonable to suppose that these currents find an equilibrium more frequently in the vicinity of Marsh Bay, one mile below Winterport, where is formed an immense bar, composed, as one can judge by superficial examination only, almost entirely of sawdust. The area of this bar must be at least a square mile. It is attached to the eastern shore, is extending rapidly, and now occupies three-fourths of the river for nearly a mile. Two other large bars have become known, and are rapidly increasing; one at Indian Point, above Bucksport; the other at Orphan's island.

The following estimate is presented of an improvement in the navigation of the river, which would open a channel above Crosby's Narrows, 150 feet wide and 18 feet deep, at lowest tides.

Commencing in section I, in the vicinity of Independence Rock, and abreast of the wharf of the Maine Central Railroad Company, the more feasible channel would curve to the southwest until it reaches Green's pier, by an excavation of 84,000 cubic yards. Green's pier, also, should be removed, as vessels lying at it are directly in the channel. Deposits, also, have accumulated above it in great quantity. As the current sets towards Low's ledge, and vessels from this cause must keep as nearly as possible in the center of the river to avoid it, excavation is proposed of 30,000 cubic yards from abreast of the marine railway to a point abreast of the railway culvert, where, in the center of the river, there is at present a depth of three fathoms at lowest tides: a total excavation in this section of 114,000 cubic yards.

Commencing in section II, abreast of the same culvert, the proposed excavation would be upon the west bank of the deposits, amounting to 144,000 cubic yards. This would open a channel through the center of the river. To the eastward of the proposed channel, from below French Signal or Severance's Point to abreast of Palmer's mill, and where vessels are now obliged to go, the bottom is hard gravel, and probably never of the depth that there was originally in the central part of the river. It would be advisable here, therefore, to restore the old channel by cutting through the deposits.

In attempting the passage of this so-called channel, at this part of the river, vessels drawing but ten feet water strike collections of edgings which are upon the bottom, are rapidly increasing, and liable at any time to completely close the river to vessels of any size, excepting with the aid of tide water.

The proposed excavation in section III is 61,000 cubic yards. This excavation to the eastward of the deeper water would be necessary because the current sets vessels towards Emery's Point, and all the deep water on the west side of the river is practically useless. Vessels now, to avoid the rocky shore, hug the bank of edgings as closely as possible.

The proposed excavation in section IV is westward of the deeper water to enable vessels to keep nearer the center of the river, and avoid the rocky shore of the east bank, towards which the current sets. This excavation extends to abreast of Stern's mill, and is estimated to be about 118,000 cubic yards.

about 100,000 cubic yards.

This material, if excavated, must be deposited below Fort Kn miles from Bangor.

I have the honor to be, very respectfully, your obedient ser

J. A. SULLIVAN

Sub-Assistant Coast Sur

T 13.

CUSTOM-HOUSE DISTRICT AND PORT OF BANGOR,

September 10, 1

SIR: In reply to your communication of the 10th ultimo I hav honor to state that all that part of the Penobscot river referred to this collection district at and near the city of Bangor.

The amount of revenue collected at said Bangor, the nearest p entry, for the last year was:

Gold	$49,8
Currency	4,8
Total	54,6

As bearing upon the question, "what amount of navigation and merce would be benefited by such improvements?" I submit the f ing statement of the business transacted, in part, at this city and for the year 1866.

Number of arrivals, foreign .....
Number of arrivals, coastwise, (over 50 tons).....
Number of arrivals, coastwise, (under 50 tons .....

)ifferent vessels arrived: steamers, 9; ships, 3; barks, 14; brigs, ; schooners, 590; sloop, 1; total, 723.
Vhole amount of tonnage, (new measurement,) 69,034 tons.
'essels built and launched: 1 ship, 3 barges, 5 brigs, and 3 schoon- total, 12; 5,009 tons.
)ne first class steamer, carrying passengers and freight, plies regularly ween this port and Boston, Massachusetts, making two trips per week; another of like character, (1,300 tons and costing $250,000,) has week commenced running upon the line. One steamer, of like racter and employment, is also plying regularly between this port Portland, making three trips per week.

IMPORTS BY WATER.

	Weight, tons.	Value.
)7 hogsheads molasses	2,156	$176,841
309 bushels salt	912	12,154
25,000 pounds sugar	762	176,750
50 tons plaster	1,260	3,150
480 barrels flour	5,212	533,280
32 barrels pork	582	125,370
,738 bushels corn	7,300	312,882
50 tons coal	9,360	84,240
,000 clapboards	417	25,020
,000 shingles	71	3,200
000 quintals fish	1,400	125,000
00 barrels mackerel	150	15,000
00 barrels pickled fish	150	7,500
Total	29,732	1,600,387

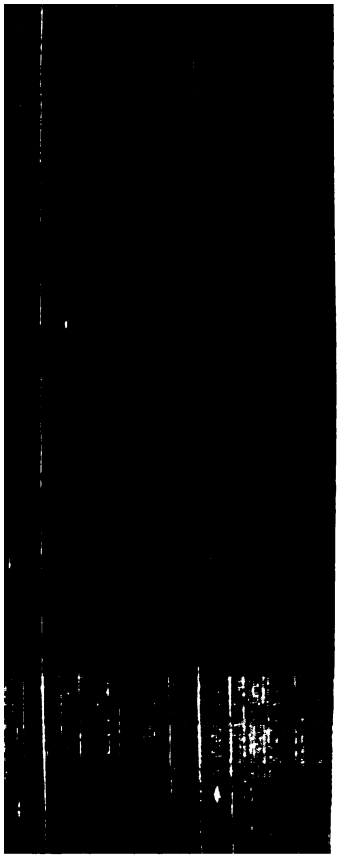
IMPORTS BY MAINE CENTRAL RAILROAD.

	Weight, tons.	Value.
254 barrels flour	2,069	211,794
435 bushels corn	460	19,722
900 bushels oats	890	41,850
Total	3,419	273,366

'otal value of imports by water and rail, $1,873,753.

EXPORTS BY WATER.

	Weight, tons.	Value.
,055 bushels potatoes	12,129	$264,580
10 squares roofing slate	1,252	83,332
38,800 bricks	5,338	21,352
,147,606 feet long lumber	592,869	3,794,361
)rt lumber, estimated one-quarter value)ng lumber	143,217	948,590
sts, spars, ship lumber, and hard wood umber	23,870	124,230
Total	778,675	5,236,445



of Brewer, on the opposite side of the river, 2,835; the two may estimated at 25,000.

This port is the highest navigable point upon the river, and a miles inland from the coast-line, making it, with its connecting railway, the commercial *entrepot* and business centre for a ter 14,000 square miles, (larger in area than the States of Massachuse necticut, and Rhode Island,) and a present population of about people. The business of the port will not diminish as the more v growth of the forests, upon which it now so largely depends, is d but will increase in double, in treble, and in tenfold proportion as t of railway shall be extended into the interior, thereby making the ing wood and timber more valuable even than the rich product removed, and bringing to the nearest navigable tide-water, fi immense deposits of argillaceous slate in Piscataquis county, ine ible supplies of the best roofing slate produced on the globe; an ing up to manufacturing improvement the vast water-power affo the Penobscot and its tributaries. A competent engineer has es that from Old Town, 12 miles above the bridge connecting Ban Brewer, the main river alone has an available water-power equ in the draught to 40,000 horse power, having a fall in that dis 100 feet. This hidden wealth, these slumbering powers, great and accessible beyond any other in the country, must soon be u and wakened into life and made busy in the employment of manuf capital, skill, and labor, their products crowding each avenue c portation from the lakes to the sea, and swelling the commerc country.

* * * * * *

Most respectfully, your obedient servant,

JOHN H. RICE,
Collector of Cu

Brevet Brigadier General GEO. THOM,
Lieut. Col. Corps of Engineers U. S. A., Portland, Maine.

"Survey of military defenses;" "purchase and repair of instruments;" "removing obstructions to Willamette river;" "survey and examination on the Pacific coast." In addition to these I am the engineer of the 12th and 13th light-house districts, and a member of the board of engineers for the Pacific coast.

The operations under the above-mentioned appropriations will be described in the order named.

SURVEYS OF MILITARY DEFENSES.

During this year I have had no opportunity of making a reconnoissance in person. During the fall of 1867 I have had two assistants in Nevada who accompanied a party sent out by the State geologist of California, by which means I have been able to collect information (the only expense being the pay of the assistants) which has resulted in a map, quite in detail, of a large portion of that State. The map was completed and forwarded to the headquarters corps of engineers. During the greater portion of the year I have had an assistant in Arizona, sent there on the verbal order of the general commanding the department of California, to report to the officer commanding district of the Verde. As no special facilities were afforded him in the way of escorts he was able only to collect such topographical information as could be obtained by accompanying scouting or other parties sent out for a different purpose than the collection of topographical information, and hence the results have been meager.

As an engineer officer arrived here in October last who has reported to the general commanding this military division, this assistant has been transferred to him.

The results of observations and investigations in meteorology and hypsometry, which had occupied much of my time during previous years, were sent to the Chief of Engineers in February of last year, with a request that they be published. This request having been submitted to the honorable Secretary of War, and having been granted by him, I was ordered in September last to proceed to Washington on temporary duty for the purpose of making arrangements for superintending the publication. Having performed that duty, I returned to my station here. During the year the collection of data for elucidating some of the parts of this subject still obscure have been continued, but in June last an order was received to stop further expenditures for that purpose, and to close my office under the appropriation, "surveys of military defenses."

The following is a statement of the amount received and expended during the past fiscal year on account of "surveys of military defenses," viz:

On hand July 1, 1867	$3,667 00
Received during the year	22,062 92
Total accounted for	25,729 92
Expended during the year	24,067 64
Balance on hand June 30, 1868	1,662 28

Which amount has since been deposited to the credit of the United States assistant treasurer at San Francisco, California, thereby closing my account with the United States under this appropriation.

Expended during the year	1,1
Balance on hand June 3, 1868	6

REMOVING OBSTRUCTIONS TO WILLAMETTE RIVER.

The operations on this river during the past fiscal year have be fined to dredging on Swan Island bar, and removing snags from th and the one at the mouth of the river. As the various machin vessels furnished me by the city of Portland required extensive ing and calking before they could be used, they were put on th early in July and after receiving the necessary repairs were la and towed to Swan Island bar, where the work of dredging comm on the 10th of September, the river having fallen sufficiently to of work being done. The cost of these repairs was $9,375 93. Th of dredging continued until the end of November, when it was s by high water. The following is the result:

Amount of material removed by dredging, 18,184 cubic yards.

Amount expended during the period of dredging, $10,484 48.

Cost per cubic yard, 57.65 cents.

A channel had been cut 100 feet wide, 900 feet long and to a d 15 feet at extreme low water.

The average depth of the excavation was 4.18 feet.

The river continued too high for dredging until in February. 20th of that month work was resumed and continued until the 1 April, when it was again interrupted by the spring freshet.

During this period of work the amount of materials removed by ing was 7,320 cubic yards.

Expenses during the period, $4,607 19.

Cost per cubic yard, 62.94 cents

A channel of the same width and depth as before was excavat 331 linear feet. The average depth of the excavation was 5.9 fe

As the vessels and machinery were in good condition and re

From the pilot of the Columbia river below the mouth of the Willamette, I learn that at the lowest stage of water and tide there is 17 feet, and at high tide 19 feet. Hence it would be desirable to deepen the channel to at least 18 feet of water, as was originally intended. To dredge a channel of that depth at Swan Island bar would require the removal of 50,000 additional cubic yards of materials at a cost of $31,200. The amount to be removed at the mouth of the river has not yet been estimated, as a survey for that purpose has not been made, but one will be made before dredging can be commenced again. The survey that was made after work was stopped in November last, on account of the rise in the water, showed that no material change or filling up in the channel had been caused by the winter freshet. The result of the more severe spring freshet has not been as yet ascertained. If the amount asked for in my last annual report has been appropriated ($25,000) an additional amount of $10,000 will, I think, be sufficient to make a channel in the river of 18 feet.

I am directed to report on the following 11 points, which I do to the best of my ability:

1st. A survey of Swan Island bar was made after work was suspended in November last, on account of a freshet in the river, and also one at the mouth of the Willamette. Work was again resumed in February and continued for nearly two months. The plan adopted was for dredging with a view to secure a channel 100 feet wide and 15 feet deep at extreme low water.

The items of expenditures have been as follows:

Original repairs of dredger, machinery, scows, &c	$9,375 93
Advertising for proposals	186 78
Dredging during first period of work	10,484 48
Expenses during first interval when no dredging was done	358 66
Dredging during second period of work	4,607 19
Expenses during second interval	271 45
Total amount expended during the year	25,284 49

2d. It is estimated that the amount asked for last year of $25,000, with an additional appropriation of $10,000, will complete the work. It may require a small amount annually to secure constantly 18 feet of water in the channel.

3d. If the amount asked for last year has been appropriated, no more can be profitably expended during the next fiscal year.

4th. The collection district is Astoria, Oregon.

5th. The nearest town is Portland, Oregon.

6th. The amount of revenue collected is unknown to me.

7th. The amount of commerce and navigation to be benefited by the completion of this work is large, and increasing. Steamers drawing 15 feet of water run from San Francisco to Portland regularly three times a month except when stopped by extreme low water at the bars now partially removed.

8th. Proposals were advertised in papers of San Francisco and Portland, and but one bid was received, which was by the city of Portland. The amount of the bid exceeded the amount of the appropriation then available. A second proposal was advertised, but no bids were received. Hence the work was done by hired labor.

9th and 10th. Hence no contract was made.

11th. The following are the amounts received and expended during the

The only operations under this appropriation have been on the Columbia river. The object of making a survey of the upper Col river was to determine the size and position of the sunken rocks various rapids, with a view of obtaining the data necessary to est the cost of their removal, so that eventually there should be a suf depth of water over these rocks during the lowest stage of the ri enable the largest size boats on it to navigate it with safety at all

Between the Dalles of the Columbia river and the mouth of river are six rapids, all of which contain rocks which should be rei to secure seven feet of water at the lowest stage. Of these, four have been surveyed during the period of this fiscal year, when could be done, namely, between the 1st of September and the December. The result of the survey has shown that the amount of to be removed in each rapid is as follows:

	Cu
John Day rapids	
Squally Hook rapids	
Devil's Bend rapids	
Hematilla rapids	

There are two more rapids still to be surveyed, the amount of on which is estimated to be as follows:

	Cu
Rock Creek rapids	
Homily rapids	

The only way of removing these rocks is by blasting. An at was made at the lowest stage of water, last November, to explod pounds of powder on the rock known as John Day rock, but on ac of the rapidity of the current the attempt failed. An attempt w made this fall to remove several of the rocks for the purpose of obta

apids, the place of the soundings being fixed by synchronous vation, taken with theodolites by two observers. The amount ıded during the year has been $11,510 16.

The amount required to complete the survey will be $2,400; but, nnection with it, experimental blasting will have to be made to a closer approximation than is given above for the cost of blast- or the survey is intended as but a preliminary step to the removal e rocks on the rapids.

The amount that can be profitably expended during the next fiscal is $8,100, besides cost of such other surveys as may be ordered ıg the year.

ı. The collection district is Astoria.

ı and 6th. I have no means of ascertaining the amount of revenue ted at the nearest port of entry.

ı. The amount of commerce is large, and increasing.

ı, 9th, and 10th. The work was not done by contract.

h. The following is the amount received and expended during the iscal year on account of the appropriation for "examinations and ys on the Pacific coast:"

ıand July 1, 1867	$6,558 85
ived during the year	15,117 25
amount received and on hand	21,676 10
nded during the year	11,510 94
ıce on hand June 30, 1868	10,165 16

tal of the amount appropriated has been $50,000, of which $24,437 is ındrawn from the treasury. The total amount expended from this ɔpriation up to the end of the last fiscal year is $15,397 84.

appropriation is asked for next year.

e work has been under the immediate direction of Lieutenant Heuer, ed States engineers, and has been conducted in a very satisfactory ıer.

duties as engineer for light-houses on the Pacific coast have occu- a small portion of my time. A keeper's dwelling for the first-order house at Cape Mendocino has been erected, and the iron tower for ame is about completed, and will shortly be sent to the same locality. ht-house site at Cape Blanco, Oregon, has been purchased. Nego- ns are now pending for the purchase of a light-house site at Santa , California. The various light-houses in the 12th and 13th districts been visited, with the exception of those on Puget sound. Several ɔsed light-house sites south of San Francisco, California, have been ed and examined. Repairs to several light-houses have been made. spectfully submitted.

R. S. WILLIAMSON,
Bvt. Lieut. Col. United States Army, Major of Engineers.

ıjor General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

U 1.

ENGINEER DEPARTMENT,
Washington, March 8, 1867.

COLONEL: Your letter of 28th January, ultimo, was duly received. The instructions of this department for an examination at the mouth of the Willamette did not contemplate such extended observations as you seem to suppose, but merely the collection of the facts necessary to form a plan for improving the navigation at that point. It was thought the cost of such observations would not exceed $1,000, probably not more than half that amount.

If it is known that the channel between J. D. Percy's island and the main shore has a clayey bottom, and that the present ship channel has a quicksand bottom, and that the Columbia slough and the Willamette river maintain always a current through the channel first named, then the governing facts for the plan of improvement are known, and the dredging should be done in the channel between Percy's island and the main shore.

It was not understood from your report that these facts, if they be such, had been ascertained definitely, or that the mouth of the river had been examined by any one under your orders, but that information had been gained directing attention to the points upon which the solution of the question depended.

Very respectfully, your obedient servant,
A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers, Maj. Gen. U. S. Vols.

Bvt. Lieut. Col. R. S. WILLIAMSON, U. S. A.,
Major of Engineers, San Francisco, Cal.

P. S.—Further appropriation of $30,000 has been made for the improvement of Willamette river. A copy of the act of the appropriation, with instructions, will be sent to you for your guidance as soon as it can be obtained. J. C. W.

U 2.

SAN FRANCISCO, CAL., *February* 24, 1868.

GENERAL: I have the honor to transmit herewith the report of Lieutenant W. H. Heuer, United States engineer on the survey of the upper Columbia river, Oregon, which had been conducted by him since early in September last, other duties preventing my presence with the party. All the rapids above the Dalles, as far as and including Umatilla rapids, have been surveyed and mapped, leaving but two above, which, it is estimated, will require six weeks of time and $2,400. The amount thus far expended is $9,049 95, the amount originally appropriated $25,000, and the balance available $16,958 05. It is to be regretted that more definite data had not already been collected to guide as an estimate of the amount required to remove these obstructions to navigation; but it is proposed to make experiments during next season of low water in removing one or more of the rocks.

Very respectfully, your obedient servant,
R. S. WILLIAMSON,
Bvt. Lieut. Col. U. S. Army, Major of Engineers.

Major General A. A. HUMPHREYS,
Chief of Engineers U. S. Army, Washington, D. C.

SAN FRANCISCO, CALIFORNIA,
February 17, 1868.

SIR: I have the honor to submit the following report of operations on the Columbia river:

In accordance with special instructions from you I went to Celils, Oregon, on September 1, 1867; there organized a surveying party, consisting of Messrs. Richard Covington, W. Hammond Hall, W. P. Gray, and five laborers. The schooner Maria was chartered from the Oregon Steam Navigation Company to facilitate the survey. The survey was commenced at John Day rapids. The river was then about eight feet above low-water stage, and had a fearfully rapid current. Our resources were somewhat limited, as we had besides the schooner only one small boat or yawl, which was only 12 feet long, and with which we dared not attempt sounding in such rapid water. However, we surveyed the shore-lines and inlands at this rapid, and in the mean time sent down to Portland for a larger boat for sounding purposes; in a few days it arrived, but was utterly worthless; still we attempted to make the soundings, but in that rapid current nothing satisfactory was accomplished. Knowing that in the course of a month or six weeks the river would be much lower and the current much less rapid, I concluded to sail up the river as far as possible, putting in the shore-lines and islands of each rapid as we came to it, so that upon our return we would have nothing but the soundings to make. This was accordingly done, and occupied a month of our time. The (worthless) boat mentioned was returned and a larger and much safer one substituted. In ascending the river we surveyed the shore-lines and islands of John Day rapids, Indian rapids, Squally Hook rapids, and Umatilla rapids. Upon arriving at Umatilla rapids I found the river so low that the schooner could not with safety sail through these rapids and the steamboat could not tow us through. I wanted to get to Homly rapids, 30 miles higher up the river, but owing to the difficulties just mentioned, had to abandon the idea. So the soundings were commenced at Umatilla rapids, and as soon as this was completed we gradually worked our way down the river, sounding on every rapid mentioned until winter prevented further operations.

The survey was conducted in the following manner, viz: A suitable base-line was measured on one shore. From the extremities of this base, at each of which an observer was stationed, angles were taken to a flag man on the opposite shore, who walked from point to point. At the prominent points stakes were driven for future reference, and their positions determined by triangulation. Having one shore thus completed, the stations just mentioned as having been determined by triangulation were now used as theodolite stations for determining the other shore (the one on which the base was measured) and the islands. Tide-gauges were placed in position at suitable points, in order that the necessary reductions might be made in case the river should rise or fall during the progress of the survey. The yawl or small boat (which contained 1,200 feet of line one-half inch in diameter, a buoy, 100-pound anchor, lead-lines, signals, &c.) was then anchored in the river directly above, and a short distance from, the rapids. The theodolite men being at their proper stations, (eyes continually at their instruments,) the boat was allowed to drop into the rapid. As soon as we were in the rapid, the boat would be checked by means of the anchor line. The commands, "Ready; sound," were given from the boat; the lead would be thrown, signal flag hoisted in the boat, and the observers would sight on the lead-line where it crossed the gunwale of the boat; the sounding man

would report the depth of water to the signal man, and he would make a record of the same. Without paying out any more of the anchor-line, we would, by means of the sweep or steering-oar, swing the boat to the right or left, say 20 feet, give another signal, and sound again. When we had swung as far to the right or left as was possible, we would pay out 20 feet more of line, signal, and sound; then swing again to the right or left, again signal and sound, and so on until the 1,200 feet of line had been paid out. When this was done, the boat would be hauled up to her anchor, anchor weighed, and then dropped, say 50 or 100 feet, to the left or right of its original position, and the same operation would again take place, until the whole rapid was sounded.

As might have been anticipated, many of our soundings are incorrect, as the intensity of the current would sometimes deflect the lead-lines materially. The shallow soundings (those less than eight feet) are very nearly correct; but when 30 feet or more is indicated, the soundings are only approximate.

To make the sounding, a lead was used weighing 11 pounds, fastened to an ordinary lead-line properly graduated. We attempted to make the sounding with a wooden pole 20 feet long, in order that greater accuracy might be obtained than with a lead-line, but it was found impossible to do so, for as soon as the end of the pole would be three or four feet under water, the current would throw it as much as 45 degrees from the vertical.

In one or two instances the rapidity of the current was measured by ascertaining the length of time required for a stick of cord-wood, loaded at one end, to float between two given points in a rapid; but the results are only good for that particular stage of the river, for a difference of a few feet of water in the river makes a difference of more than a mile an hour in the current. It may seem strange why steamboats take such different channels during high water from those at low water, although the former are often the more circuitous. It is mainly owing to the rapidity of the current. During the high-water season, the boats hug the shore as much as possible, for should they, in many places, get into the low-water channel, they could make no headway at all against the current.

At Umatilla and John Day rapids, lines of level were run with a view of ascertaining the amount of fall in the river from the head to the foot of each of these rapids. This amount of fall also varies with the stage of the river; and although a rapid may be only a quarter of a mile in length, in some places on that rapid the water will fall two feet, while in other places on the same rapid the fall will be less than a foot. This is owing mainly to large reefs of rock, extending in some places almost entirely across the river. As long as these reefs are entirely under water a fall of one foot in the river above the reef will make a fall of one foot below the reef, but when the reef becomes exposed, a fall of one foot above the reef will, in some places, cause a fall of two feet or more immediately below the reef.

The current of the river on these rapids is rather peculiar. It varies in intensity, depending on the stage and fall of the river, from 4 to upward of 12 miles an hour; but between the rapids the current is very much slower, averaging about three miles an hour during an ordinary stage of the river. When the current pours over a sunken rock having three or four feet on it, the water forms large waves, extending from 50 to 200 feet on the down-stream side of the rock. Some of the waves are very large and extremely dangerous to get into with a small boat, particularly if the boat is anchored with the anchor above the rock. From the appearance of those waves one would suppose that

rent was swifter in them than anywhere else, but such is not the
In the waves, or breakers as they are commonly called, there is
:tle current, but directly on top of or over the rock the current is
:st. The under-current is much more rapid than that at the surface,
e danger just mentioned to be apprehended is that the under-cur-
ill force your anchor line to pull the nose of your boat under
Where these sunken rocks were only about a foot or so under
they would still make a "break," but the current in the "break,"
of running down stream, would have very little or no force at all.
her great difficulty in making the survey was owing to the pres-
whirls in the river. On many of the rapids where large rocks
:posed, the current would be divided by these rocks, and these
s would again come in contact on the lower side of the rocks,
vould cause immense whirls, some of them 12 feet in diameter
et deep in the center, being very much like an inverted cone.
ould gradually work down the river until they became smaller
ıller, and would finally disappear. We always managed to avoid
hirls.

bject in making the survey was to determine the size, as nearly
ble, of the sunken rocks on the various rapids, with a view to
an estimate of the cost of their removal; to have such a depth
over these rocks during the lowest stage of the river as would
he largest size boats in the river to navigate it with safety at
s. The largest boat now employed on the river will not draw
feet of water when fully loaded, so that I should think, that if
rock was removed to have seven feet of water on the rocks at
low water, that ought to be all that was required. The esti-
the quantity of rock to be removed will be based on the sup-
that they are to have seven feet water over them.

ıannel in the rapid is very tortuous, and although in most cases
ned, yet it is very difficult to keep a steamboat in them, owing
ırious directions of the currents, and frequently to the intensity
ind, which generally blows across the channel.

maps which accompany this report, many of the rocks recom-
for removal are 200 feet or more apart from each other, and it
be clear why both rocks, so far apart and having good water
them, should be removed. This I will endeavor to explain.
we have two sunken rocks 200 feet apart, but one of them
e other, in the general direction of the current. The boat is
170 feet long. She passes the lower rock and heads directly
)per one, because in the eddy of the upper rock there is little
rent. She is now nearly up to the upper rock, and must turn
one side to get out of the way of this rock. The minute she
head, the current strikes her bows; her stern still in the
boat swings, the current strikes her broadsides, and it requires
)est of management to keep her from striking broadside on the
k.

ıese rocks materially affect the strength and direction of the
ıere is no doubt. Now suppose these sunken rocks were all
what effect would their removal have upon the current? That
definitely answered at present; it would change the direction
rent somewhat, because each rock would then allow the whole
ıe current to pass over it and would not split it as is now the
ts intensity would be increased accordingly. The breaks which
s now make enable the pilots to tell exactly where the channel
e removal of them will therefore confuse them somewhat. The

rock is a hard basalt, and is not columnar like ordinary basaltic rock. That which is on the bluff banks of the river is nearly all columnar, but that under water looks as though it had been subjected to the action of intense heat, melted and then run into a lump with small sharp points sticking up. Occasionally small crevices can be found in some of the rocks in which a blast would be very effective, but those cases are very few and difficult to find. After having completed the survey this year as far as practicable, I attempted blasting on one of the rocks known as John Day Bock (really the worst rock in the river) in John Day rapids, with a view of making an estimate of the cost of removal of the other rocks. Our efforts were anything but successful. Two hundred pounds of blasting powder were put into a torpedo, which it was intended to ignite simultaneously at three points of ignition by electricity. Everything being in readiness, lines were stretched across the river from No. 1 on south shore (see map of John Day rapids) to rock No. 2, and the boat allowed to drop along this line until nearly over John Day Rock, which I intended surveying carefully both before and after the blast, to ascertain its effect; but as soon as the boat got well over the rock, a wave broke over her bows, and had we not immediately cut the line our boat would have swamped. Seeing that the boat could not be held on the rock, we returned to shore, took the torpedo on board and tried to get about 20 feet above the rock; then I intended drifting the torpedo against the rock, (torpedo being kept in position by 800 pounds of rock as anchors;) then having it fairly on the upper side of the rock, with a pressure of 20 feet of water over it, I contemplated making the blast; but we could not get above the rock in proper position, as the boat would not steer, owing to the torpedo hanging immediately over her stern, and I dared not take it and anchors in the boat, for the boat was incapable of carrying all this extra weight. After 10 hours vainly attempting to place the charge, my line (which was stretched across the river) parted, and we pulled for shore. It was now nearly dark; I then anchored the charge in 18 feet water against a bluff bank of the river, thinking that I could make an estimate by calculating the amount of rock which would be thrown down by the blast, but when I tried my battery the charge failed to explode. Next morning, while examining the wires of the battery to ascertain what the difficulty was, I found that the current had loosened one of the wires where it entered the torpedo, and that the water had been gradually percolating through this small hole all day, so the powder became thoroughly saturated, and my attempts failed. In the maps accompanying this report, the numbers indicating the soundings represent the depth of water in feet during the lowest stage of the river.

JOHN DAY RAPIDS

are in the Columbia river near the mouth of John Day river, and are 33 miles above the Dalles; the first bad rock encountered in ascending this rapid is the one known as John Day Rock. At this place during low water the river runs at the rate of nearly 10 miles an hour. In ascending boats run to the left of this rock in order to get into the comparatively slack water under the island marked No. 2; in descending they also have to keep to the left of this rock. In the cove to the southward of John Day Rock is a very strong eddy, the current of which flows directly contrary to that of the current in the channel. During extreme low water this rock barely comes out of water. To obtain seven feet of water on this rock will require the removal of 200 cubic yards of rock. The next bad rocks in this rapid are directly opposite the mouth

f John Day river and are indicated on the map by red dotted lines or by red cross. They together contain 242 cubic yards of rock. The rock hich is indicated by a small red cross I did not find, but pilots say here is one there; so I have marked it and estimated it to contain ix cubic yards of rock. Those are all the rocks that need be removed in his rapid. The channel, which is marked "high-water steamboat hannel" on the map, cannot be used during low water, owing to shoals nd rocks. Fall in the river from head to foot of these rapids is 5.3 feet. 'he next rapid surveyed is called

INDIAN RAPID.

There is always sufficient water here for the boats, and no improvements of this rapid are recommended.

We next come to

SQUALLY HOOK RAPID.

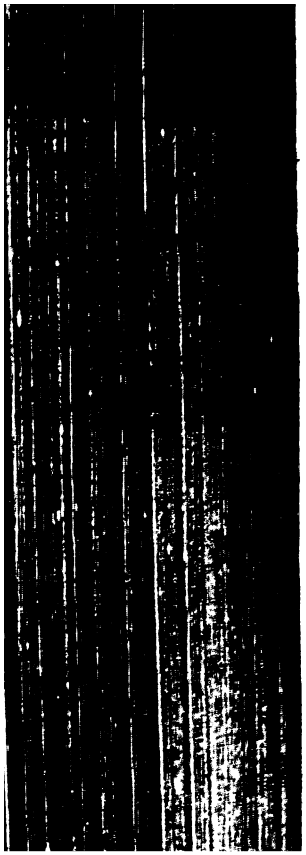
This rapid is about 40 miles above the Dalles and has several bad ocks. They are also indicated by dotted red lines. The winds have a reat deal to do with rendering the navigation of this rapid dangerous; hey blow almost directly across the channel toward the north shore. Commencing toward the right of the map, the rocks recommended for emoval contain, respectively, 66, 209, and 175 cubic yards of material.

DEVIL'S BEND RAPID

s about 100 miles above the Dalles. This hardly deserves to be called rapid. The river bed here is a large shoal flat; during low water it is ather difficult to navigate, owing to the presence of numerous large oulders; a glance at the map will show their relative positions. Blasting will only be resorted to on two or three rocks which are outcroppings of bed rock. The boulders vary in size from 4 to 10 cubic yards; hey will have to be grappled and towed to one side. The river at this lace was originally much worse than at present; but recently the teamboat company have removed many boulders.

UMATILLA RAPIDS

re seven miles above Devil's Bend, and are upwards of two miles in length; rom the head to the foot of these rapids the river has a fall of 18 feet. This apid requires more work than all the other rapids combined, as a glance t the map will show. Upwards of 2,000 soundings were made here, and s many more might have been made to advantage had time permitted. Still the positions of all the bad rocks were determined. Soundings were nly made in and near the steamboat channel, for as soon as we got out f that channel we could easily see bottom, which seemed to be one mmense bed of rock, and in but few places did the depth of water exceed ve feet. Towards the right of the map (at the upper end of this rapid) s a channel known as the high-water channel, but which is not used uring low water on account of the many rocks in it. I think it advisble those rocks should be removed, as that would give almost a straight hannel and require less blasting than would be necessary to improve the resent low-water channel immediately to its left. The rapids yet to be urveyed are known as Rock Creek rapids and Homly rapids. The survey annot be advantageously resumed until next October, and will occupy ix weeks or two months of time, and will cost $2,400. Neither of the two apids just mentioned offer very serious obstacles to navigation. From he best information I can obtain, Homly rapids only contain about eight



contend against. Taking these difficulties into consideration, an
fact that everything necessary to prosecute the work to advantag
have to be purchased here, I estimate that it will cost $28 per
yard to remove the obstructions in the Columbia river; and as
obstructions measure 4,726 cubic yards, I respectfully request th
appropriation of $132,328 be asked for.

Very respectfully, your obedient servant,

W. H. HEUER,
Lieutenant of Engine

Bvt. Lieut. Col. R. S. WILLIAMSON,
Major of Engineers.

RECAPITULATION.

*Rocks to be removed to obtain a depth of seven feet of water in Joh
rapids. (See map.)*

Rock marked—	Size ir yar
A	
B	
C	
D	
SQUALLY HOOK RAPIDS.	
A	
B	
C	
DEVIL'S BEND RAPIDS.	

UMATILLA RAPIDS.

Rock marked—	Size in cubic yards.	Rock marked—	Size in cubic yards.
.....	153	O	55
.....	1.5	P	14
.....	14	Q	29
.....	3	R	29
.....	21	S	17
.....	17	T	42
.....	26	U	56
.....	95	V	19
.....	70	W	58
.....	201	X	32
.....	127	Y	855
.....	42	Z	35
.....	95	Z	55
.....	105	Z	119
.....	35	Z	37
		Z	55

	Cubic yards.
r rapids	442
Hook rapids	450
end rapids	672
rapids	2,512
ek rapids	500
pids	150
	4,726

U 3.

SAN FRANCISCO, *March* 28, 1867.

I have the honor to make the following report in regard to the periments on Blossom Rock:

om Rock is a sandstone, rather hard, and is on a line with Alca- and Yerba Buena islands, and about midway between them. he tides are lowest the rock has about five feet of water over it. ontal section of the rock 18 feet below the surface of the water n low tide gives the greatest length of the rock at 130 feet, by of 75 feet. To obtain a depth of 18 feet water at mean low tide equire the removal of 1,000 cubic yards of stone. The experi- vere made with gunpowder with a view of estimating the cost of l of the rock. The charges of powder used were of three sizes, , 125, and 175 pounds, in order to enable us to ascertain which large would prove most effectual, due regard being had to econo- ach charge was placed in a strong, water-tight cask, in the head of which a small hole was bored to admit of the passage of the r exploding the charge; the cartridge was placed as near the of each charge as possible. Each of the casks was inserted in a sail cloth which fitted closely, and which was afterwards tarred. avy pieces of iron were then tied to each cask, one on each side, ent the tide from washing the charge off the rock. Soundings en made to enable us to find advantageous positions for the

after the blasts, deserve great credit for the admirable manner their work was done, and to their persevering efforts much of th of these experiments is due. Appended will be found the sket nished by Mr. Cordell relative to these experiments.

Owing to the stormy weather the experiments occupied n months of time. Advantage was taken of every favorable da that time, but frequently after a blast had been made the bay too rough for days, and even weeks, to make an accurate surv which retarded our progress. Before we commenced blasting, ination of the Coast Survey chart indicated quite a crevice a one end of Blossom Rock. As it appeared favorable for placing there, instructions were given to place a charge of 75 pounds pow crevice. This was done on January 29. After they thought found the crevice, the charge was exploded in 16 feet of wa rock was considerably shattered. No large masses were broke a subsequent examination proved that there was no crevice th

The second experiment took place on January 30. One hun seventy-five pounds of powder were placed near the top of the exploded in 11 feet of water. The explosion shattered the rock not materially increase the depth of water. It was then deter have an examination of the rock made by a diver in armor. He that "the rock was broken considerably where the two blasts h place; that no large fissures had been made, and that the rock jagged in many places." He brought up an armful of specime rock which we had broken off.

Third experiment, February 9. One hundred and seventy-fiv of powder were placed near the west end of the rock, in 14 feet and exploded. Water was thrown to the height of 40 feet, and vey indicated that about 11 cubic yards of stone had been rem

Fourth experiment, February 19. Two blasts of 125 pounds e exploded in succession in 20 feet of water. About 15 cubic

Eighth experiment, March 7. The remaining charge of 175 pounds was exploded in 18 feet of water; a large volume of water, probably 50 feet in height and nearly as much in diameter, was thrown up. The survey showed that eight and one-half cubic yards of stone had been removed.

The experiments just made show that the charges of 175 pounds of powder produced the best results, averaging about 6.17 cubic yards per blast.

The 125-pound charges averaged about five cubic yards per blast, while the 75-pound charge produced but little effect. It is thought that much loose rock remained where the blasting occurred, which, had it been removed, would have increased the average somewhat, probably 30 per cent. I am also inclined to think that much better results would have obtained had we used strong iron vessels to contain the powder, instead of wooden casks.

Number of charges of powder used	12
Number of experiments	8
Total amount of stone removed in cubic yards	475
Total expense incurred, including use of surveying vessel Marcy, officers and crew	$3,417 42
Average cost of removing, per cubic yard	69 05
Cost of removing Blossom Rock at this rate to a depth of 18 feet water, mean low tide	69,050 00

The above amount would be the cost of removing the rock to this depth if we could continually average a pressure of 18 feet water on each charge; but when the pressure is less, which necessarily follows as we approach the top of the rock, the expense per cubic yard increases rapidly; and, judging from experiments one and two, I do not think that twice the amount, or $138,100, would be too large an estimate. To obtain a depth of 25 feet water, mean low tide, would require the removal of 3,345 additional cubic yards of stone, which at an average cost of $69 05 per cubic yard would make the cost of the additional seven feet of depth cost $230,972 25, or for the removal of the whole rock to a depth of 25 feet, mean low tide, a cost of $300,022 25.

A few suggestions might not be out of place here. If Blossom Rock must be removed, I think it can be done more economically by drilling, and afterwards by surface blasting, than by surface blasting alone. But as the tide is very strong over the rock, drilling might at first be considered rather a difficult matter. This can be easily overcome by building a framework of timber and iron as per annexed figure, setting it in the rock where we wish to drill, placing a portable 4-inch cylinder engine on top of the frame, drilling with the engine to the required depth, inserting the charge, (nitro-glycerine or powder,) removing the frame, and exploding the charge by means of a battery. After sufficient rock had been removed in this manner to enable us to have a depth of 18 feet of water at high tide, then surface blasting can be advantageously used.

Estimated cost of removing Blossom Rock in this manner to a depth of 25 feet water, low tide:

Cost of engine, sliding boxes, pipe, spuds, &c	$2,173 50
Schooner for powder and quarters for men for one year	3,000 00
Scow	1,500 00
Engineer for one year	3,600 00
Four laborers, at $150 per month, 1 year	7,200 00
Overseer	3,600 00

Description of frame proposed to be used in drilling Blossom Roc

The three vertical legs are of wood, in each of which is an iron with cogs, technically termed "spuds," and which are made to wo and down by means of a cog wheel fastened to each leg. The hori frames A B C and *a b c* are of wood. The engine is placed on the of *a b c*. The upper frame A B C is used to hoist the engine fro scow to its proper place as well as to give additional strength to the H I K are iron bars; they are four feet from the bottom of the of the frame. The whole frame is now placed on a scow, the iro H I K resting on her decks, the legs of the frame beneath the iron hanging over her sides. The scow is taken to Blossom Rock, on there is five feet of water, mean low tide; is anchored there unti before the time of low water; the spuds are allowed to slide down they rest securely on the rock; are then made fast, engine raised proper place, and scow hauled away. All is then ready for drillin

U 4.

HEADQUARTERS CORPS OF ENGINEERS
Washington, D. C., June 22, 18

GENERAL: In reply to the request of the chairman of the Comm on Commerce, United States Senate, of June 5, for information rel to the necessity and propriety of legislating in accordance with the tion of citizens of California for an appropriation to improve the ha

In the letter of Mr. D. B. Hoffman, accompanying the petition, it is stated that "the destruction of said harbor is not caused by its present channel inside of the Heads being filled up, as this portion of it is now the same as it was when sounded 15 years ago; but the sand, &c., which is brought down the river annually by the freshets and floods, is washed out by the tide and deposited on the bar at the entrance. This is what it is desired to remedy, and what would be effectually remedied by turning the said river into False bay as proposed."

This statement of Mr. Hoffman would seem to point to the bar at the entrance as the obstacle. Whether the bar is formed from the sand brought down by the river, or by the current alongshore outside the Heads, or whether it is not due to the combined influence of both, is a question that can only be determined after a detailed survey and examination have been made of the whole subject. This investigation may be made under the appropriation for surveys and examinations on the Pacific coast, for which an estimate is now before Congress.

The letter of the chairman of the Committee on Commerce, United States Senate, is herewith returned, together with the petition.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Major General J. M. SCHOFIELD,
Secretary of War.

U 5.

SAN FRANCISCO, *April* 13, 1868.

GENERAL: Your letter of August 12, 1867, directing me to prepare and transmit to the headquarters of the corps a project and estimate for the improvement of the harbor near Point Sal, California, as soon as I shall have received the map of the survey and other information bearing upon the subject from the proper assistant of the Coast Survey, was received by me a few days before I sailed for the east on temporary duty in Washington and New York. On my return to this place in February last, I found there had been sent to my office for my information, from the Coast Survey office, a tracing of the roadstead near Point Sal. Having made an examination of the map, I concluded that an examination of the locality also would be advisable, to obtain full data from which to form the project; and as other duties prevented me from doing this in person, I have sent my assistant, Lieutenant Heuer, United States engineers, to the point for the purpose. He having returned, and given me the information he gained, I have the honor to submit the following report, with project and estimate:

The indentation on the coast between Point Sal and the point some two miles below is called on the Coast Survey map "the roadstead under Point Sal," and this is its proper designation, as in its present state it is not a harbor, which is defined to be a port or haven. While the distance between the two salient points is about two miles, the depth of the indentation is less than one mile. The direction between these two points is west 25° north, and east 25° south; hence the roadstead is open to southeast and southwest winds, which are the prevailing winds during the winter months, when violent gales are often experienced; and hence a harbor of refuge at this or any other point between San Francisco and

San Diego would be a great benefit to navigators. During the summer months the prevailing winds are from the northwest, and are seldom violent. Against them Point Sal forms a natural protection. The latitude of Point Sal is 34° 55′ north, the longitude about 120° 40′ west, and the magnetic variation about 13½° east. In the Coast Survey tracing furnished me, a meridian line has been drawn, but the tracing exhibits no evidence to show whether the line is true or magnetic; but from the examination of other maps of the coast I infer that it is a magnetic meridian.

Lieutenant Heuer reports that from the extremity of Point Sal, at the sea level, the ground gradually rises, in less than three-fourths of a mile, in a northeasterly direction, to a Coast Survey station marked on the tracing △peak, the altitude of which is 1,200 feet. The country in the immediate vicinity of Point Sal is hilly, the peaks varying from 1,000 to 1,500 feet above the sea. Towards the northwest, distant about six miles, and on the seaward side of the hills, there is a large sand flat, two or three miles long, and nearly as broad. Towards the northeast, distant about six miles, and in rear of or beyond these hills, the country is one vast agricultural plain, embracing many thousand acres of farming land.

The country within a circuit of 100 miles from Point Sal is sparsely settled. Each of several ranchos near the point, containing over 40,000 acres each, is owned by one person. The rancho on which Point Sal is situated contains 43,000 acres.

The hills back of this roadstead are composed of metamorphic sandstone, quite hard and brittle. This rock can be conveniently quarried in blocks or masses of large size. From its nature, it is probable that the action of the waves, should the blocks be deposited in the sea, would have the effect of gradually wearing the edges and reducing the size of the blocks.

To make a harbor of this place two arms would have to be built out into the sea. Their suggested positions are shown by the red lines of the tracing. One would start from near the extremity of Point Sal and run to Seal Rock, and from thence, in a direction about east 25° south, magnetic, making the whole line 4,620 feet. The other arm would start near the point marked on the tracing as O. Reef, and would extend, about west 25° north, magnetic, for a distance of 5,430 feet. The two arms of this suggested breakwater would be separated by 200 yards. These could give a harbor containing 444 acres, with a depth of water 3 fathoms and upwards; 381 acres, with a depth of water of 4 fathoms; 319 acres, with a depth of water of 5 fathoms; 254 acres, with a depth of water of 6 fathoms; 157 acres, with a depth of water of 7 fathoms; 52 acres, with a depth of water of 8 fathoms.

The crest or top should be 30 feet in width, and five feet above the highest spring tide. The interior slope should be 45°. The portion of the exterior slope that is above the highest water should be two horizontal to one vertical. Between the highest and lowest spring tides it should have a slope of 11 horizontal to 2 vertical; and below the lowest spring tide it should have a slope of three horizontal to one vertical. Such a breakwater would require 2,841,268 cubic yards of materials, as the one arm would contain 1,455,266, and the other 1,386,002 cubic yards.

The average of five estimates (made by as many different engineers in 1847) for the construction of Dover breakwater was $15,989,878. That breakwater was estimated to require about 6,500,000 cubic yards of stone, which would make the estimated cost per cubic yard $2 46.

The Plymouth breakwater cost $3 50 per cubic yard, which, at the

me rate, would make a breakwater at Point Sal (of 2,841,268 cubic rds) cost $9,944,438, or, in round numbers, $10,000,000.

Since the structures above referred to have been built, the price of ›or generally has been greatly increased, and the price of labor in ılifornia is very high. It is probable that the price per cubic yard of ə suggested breakwater at Point Sal would be considerably greater an $3 50 per cubic yard.

But whether the estimate for this one is large or not, all experience s shown that no breakwater of any magnitude, intended to form an ;ificial harbor or a sea-coast, must cost millions of dollars. If the ne comes when the interests to be protected are so great as to demand ə construction of a breakwater at some point between San Francisco d San Diego, a board of engineers should examine every point thought be eligible for the purpose, and spend much time, and make experi-nts, and collect statistics, so as to determine which point is best.

When one place has been selected and minutely surveyed, one engi-er should be selected to visit, examine, and report upon all similar eakwaters in Europe and America. After gaining experience from s study, he should make out a detailed project, explaining exactly the y in which the work should, in his opinion, be done; the kind of ma-inery to be employed, the materials to be used; whether natural ne, as in England, or artificial stone, as at Algiers; and, in fact, erything giving light upon the subject, with detailed estimates based more reliable data than the reported cost of somewhat similar struc-es built a decade of years ago. When the persons who have the thority approve and adopt the plan, the work can commence.

I have the honor to be, very respectfully, your obedient servant,

R. S. WILLIAMSON,
Major of Engineers, Bvt. Lieut. Colonel U. S. A.

General A. A. HUMPHREYS,
Chief of Engineers U. S. Army.

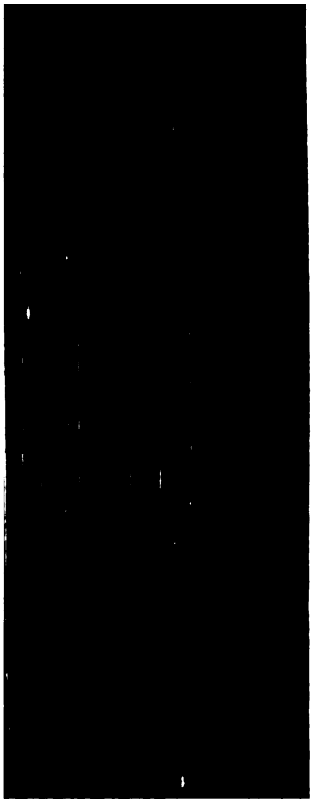
APPENDIX V.

OFFICE OF PUBLIC BUILDINGS, GROUNDS, AND WORKS,
U. S. Capitol, Washington City, D. C., September 30, 1868.

GENERAL: The following report of the condition, at the close of the t fiscal year, of the several public buildings, grounds, and works in charge, and under my supervision, is respectfully submitted for your ısideration.

RIVER CHANNEL IMPROVEMENTS.

By orders from headquarters Corps of Engineers, No. 67, dated July 27, 67, the examination and surveys of the Potomac river, in the District Columbia, were assigned to me, with instructions to report upon some ;tem of improvement in reference to its navigation. A detailed report, ;h accompanying maps of the last survey, and also of those made in ›vious years, was presented on the 30th of April, and plans submitted accomplishing the object. The following is a brief recapitulation of ə suggestions then made, and which subsequently met your approval. was recommended in the first instance to dredge out that portion of ə Virginia or Georgetown channel where the existence of the shoal water



executing the different sections of the work; the sum total is n for its entire completion, and the whole amount can be pr expended in the present fiscal year, should an appropriation b during the early part of the next session for that purpose. The i ment is located in the commercial district of Georgetown, and t nage of vessels belonging to the district amounts to 22,455 ton collector furnishes the following information:

The number of vessels entered for the last year, (1867,) 373: number of vesse for same time, 205. You cannot judge of the amount of business done in thi from the number of vessels entered and cleared, for those in the coasting trad required to enter or clear at the custom-house, unless they have foreign goods o spirits on board; there are at least 20 vessels arriving here which do not enter o each one that has to do so.

Besides the very great advantages which would ensue to Was and Georgetown, and in which the general government is deepl ested, by the contemplated improvements, in a business and com point of view, other most beneficial results would be derived fr execution. The low marshy flats which now line the river fron city, tending so much to induce an unhealthy condition of the phere, and presenting so unsightly an appearance, would be re and in a short time, it is to be hoped, greatly enhance the ext beauty of the public grounds about the monument which is being to the memory of Washington. Again, by opening a cut for Tiber, or what is now styled a canal, to pass into deep water of channel, the sewerage of the city, a subject which should receive t careful and studied attention on the part of every inhabitant, w scoured off by the strong current of the river, instead of spreadi the flats and generating pestilential vapors with which to inf whole community. These great advantages will certainly des consideration of Congress, of the corporations of the two cities every reflecting citizen, and compensate for the comparativel

that has been required. The Navy Yard bridge, over the same branch, is constantly in want of repairs to the flooring of the roadway, in consequence of the great amount of travel over it. A new walk has to be laid for pedestrians, and the causeway approaching it requires to be raised and re-graveled. Uniontown, at the eastern terminus of the bridge, is constantly increasing in numbers, and a large proportion of its population and that of the surrounding country, together with great quantities of produce, pass over this bridge into the city of Washington. Application has been made to Congress to incorporate the Uniontown and Washington City Railroad, with authority to construct and lay down a double or single track railway through and along certain avenues and streets, and then across this same bridge. A resolution of the Senate of the United States, June 20, 1868, directs me "to make a survey of the lower bridge, known as the Navy Yard bridge, across the Anacostia, and report a plan for a permanent structure across the same, at or near the present site, capable of sustaining a railway track and cars, with a footway on each side of the carriage track, with an estimate of the cost of the same." Surveys for the site have been made, and a report with plans will be in readiness to submit to you in time for the next session of Congress.

The Long bridge was placed in as good repair during the last year as the small amount of the appropriation would admit, and has, until very recently, been kept in a passable state.

The draws, however, have been constantly getting out of order, and lately it was deemed necessary to suspend travel over the bridge in order to replace the heavy weighty one, near the north terminus, by an entirely new and lighter plan, and to thoroughly overhaul the south one. In addition to this improvement repairs are being made to the roadway and footwalks, and the brick walls and railing are being renovated and whitewashed. Owing to the general worthless construction of this bridge annual appropriations will be required to preserve it even in passable condition. Work is, and will be, required to make it stand until a more substantial, suitable, and architectural structure be built to span the magnificent Potomac. In the event of the improvement of the channels of the river, the causeway should certainly be removed. In my report upon this subject it was stated "that the bridge question was so intimately associated as to necessarily form a part of the discussion." It continued to say that some "very interesting and comprehensive reports in reference to bridging the Potomac at several points have been carefully examined, and the subject found to be very thoroughly exhausted. Should either of the plans proposed in reference to the present site of the Long bridge be adopted, it would necessitate the removal of the causeway." In the judgment of the engineers who have examined the subject, the present locality of the bridge does not possess any particular advantage, save more direct communication between the city and the Virginia shore, while it certainly possesses very great disadvantages. The necessary greater length of a permanent bridge at this point would render its construction proportionately more expensive, and it could not be well built without, as it now does, seriously interfering with navigation; one or more draws would certainly be required, which must prove a very great hindrance to travel, especially that by railway, as well as to the passage of vessels. The greater danger to travelers is a matter to be carefully considered, as many accidents are constantly occurring from carelessness in attending the draws. The Long bridge has been for so many years the means of intercourse between the city and the opposite shore, that it would be very difficult to divert attention from the old well-beaten track.

The Aqueduct bridge, over those splendidly built piers constructed some 30 years ago by Colonel Turnbull, is now being arranged, in addition to canal purposes, for ordinary road travel, by the company leasing the Alexandria canal. It is to be opened to the public on or before the first of March of the coming year. Certain rights and privileges have been granted this company by the government and the State of Virginia. By an act relating to the Alexandria canal, approved July 27, 1868, the company is authorized and empowered to maintain and operate said aqueduct, and to erect, build, operate, and maintain upon and over the stone piers upon which the aqueduct now rests, in conjunction therewith, a bridge of wood, iron, or stone, with one or more ways for the passage of persons, animals, and vehicles, and also with one or more tracks for the passage of engines andc ars; and that as soon as the Chief Engineer of the army shall certify to the Secretary of War that the said bridge is completed, the company may demand and receive certain specified tolls.

The Chain bridge over the Potomac, at the Little Falls, about three miles above Georgetown, is still in a very dilapidated condition. Owing to the late period of the last session of Congress at which the appropriation was made for repairing it, very little has been done. Work will be resumed upon the receipt of the necessary material and pushed rapidly forward. It is believed that the sum appropriated will be sufficient to place it in good repair and preserve it so for many years; the ordinary wear and tear of the roadway will alone have to receive attention. There is a very great amount of travel over it; large quantities of produce and thousands of head of cattle reach the Georgetown and Washington markets by this bridge.

Average amount of travel over Potomac, Navy Yard, Little Falls, and Benning's bridges per month.

Name.	Foot passengers.	Horses and riders.	Horses and wagons.	Teams and wagons.	Cattle.	Hogs.	Sheep.	Vessels passing the north draw.	Vessels passing the south draw.
Potomac (Long) bridge.	18,604	2,299	4,544	3,894	504	780	334	280	700
Navy Yard.....	21,654	1,195	7,408	5,920	367	263	412	1	.....
Little Falls.....	5,020	3,968	4,130	5,079	2,177	900	.....	.....	.....
Upper (Benning's).....	1,330	435	1,210	1,704	133	60	3,567	.....	.....
Total.....	46,608	7,897	17,292	16,597	3,181	2,003	4,313	281	700

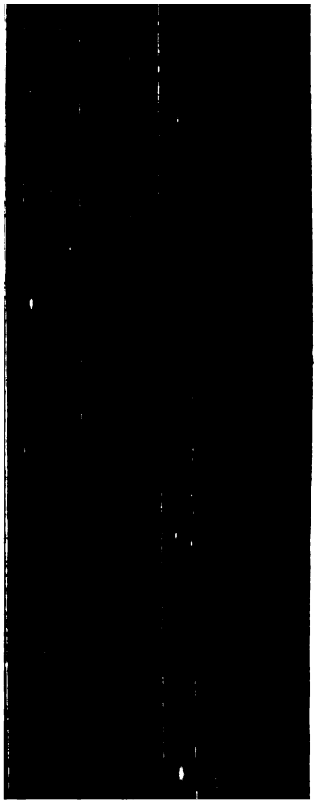
PUBLIC SQUARES, RESERVATIONS, NATIONAL PARK.

In my last annual report it was stated that "the plan adopted by General Washington for laying out the capital of the nation consists of wide streets and avenues intersecting each other; the former running from north to south, designated by numbers, and from east to west, called by letter, cross each other at right angles; these are again cut diagonally by avenues bearing the names of the different States of the Union. In consequence of this system many public places have been formed, consisting of triangles, circles, and squares; in different parts of the city sections are set apart as reservations for the benefit of the citizens and for public buildings. Many of these have already been beautified, and the

remaining ones should be improved as early as possible. While adding so much to the appearance of the city, they at the same time largely contribute to the health, pleasure, and recreation of its inhabitants."

Lincoln square is located at some distance to the east of the Capitol, and is the only public reservation in that section of the city which is undergoing any improvement. It is one of the largest squares, being about 825 feet in length by 335 feet in breadth, and was especially ordered to be laid out by act of Congress, as a tribute to the memory of the distinguished man by whose name it is called. Not much more can be done towards its adornment during the present fiscal year than to fill it up to the proper grade of the surrounding avenues and streets, and in the fall to plant trees and shrubbery. No less than four avenues, Massachusetts, Kentucky, North Carolina, and Tennessee, and four streets, East Capitol, Eleventh, Twelfth, and Thirteenth, radiate from it, and the main thoroughfare, Pennsylvania avenue, is not far distant; it is therefore one of the most accessible squares in the city, and will in time become one of the most ornamental should the necessary appropriations be made to continue the improvements which have been commenced; the one for the present fiscal year will soon be expended, and another is submitted for continuing the work.

Capitol grounds.—No appropriation has been made for some time for the improvement or preserving these grounds; save to trim the trees, mow the grass, and clean the walks, very little has been attempted. The grounds in the east have been a great resort for parties desiring to indulge in the game of croquet, and on one day in the week becomes a favorite place for the denizens of the city to listen to the music of the band attached to the marine corps. Owing to the trampling of feet over the grass, and the severe drought during the summer, it at one time failed to present a very attractive appearance. Orders had to be given to cease the favorite game, and through the intervention of refreshing showers the grounds soon resumed their accustomed attractiveness. In consequence of the gradual rise of these grounds away from the Capitol, the view of that magnificent building is concealed from the more eastern sections of the city. The grade should be made to descend from the structure, so as to place it in a more commanding position. The earth excavated from this section will be needed in the further extension of the public grounds surrounding the Capitol. A bill for the purpose of enlarging them has been introduced into the Senate, proposing "to extend them between First street east and First street west, northwardly to the south side of north B, and southwardly to the north side of south B street, including, in addition to so much of the reservations, avenues, and streets as are necessary for such extension, the two squares designated on the plan of the city of Washington as 687 and 688, respectively." The enlargement has been carried on under the immediate supervision of the architect of the Capitol. It is to be regretted that heretofore the appropriations have been so very limited as scarcely to be able to make an impression or give an insight into the plan of the proposed improvement. It is to be hoped that future legislation will remedy this defect, and that ere long the magnificent pile will stand out in all its superb proportions, untrammeled and not disfigured by its present surroundings. In this immediate connection attention should be directed to that part of the city by which the great line of railroad from the north approaches the capital. It is a constant marvel to every visitor and traveler that so little has been done towards the advance of improvement in that direction. Under the very eaves of the Capitol, within a stone's throw of its north portico, the eye is forced to rest upon one of the most unfinished, unsettled, and offen-



from having been left ungraded for many years past; no attem
been made to render it even accessible, much less to improve it.
part of the city streets are being opened and the grades establis
here we have the spectacle of a fine broad avenue, directly in fro
north wing of the Capitol, left in a most deplorable condition
legislative action should be taken to remedy the evil by chan
line by which the railroad enters the city; if correctly infor
company, some years ago, proposed a plan with that object in vi
grounds to the west of the Capitol have always presented a ve
some appearance, and have been kept in excellent order. I
quence of their being of rapid growth, a great many very ordina
principally species of poplar, have been planted and allowed to
and spread, to the great injury and crowding of more valu
beautiful kinds; it is my intention to have them removed at
day. The iron fence and its foundations will be repainted and re
and other repairs made, an appropriation having been made
purpose.

The improvements in the botanical garden are progressing ve
factorily. The work on the culvert, which so beneficially tr
the exposed bed of that portion of the Tiber passing through the
into an extensive sewer, and enables a uniform grade to be est
was suspended last year in consequence of the smallness of th
priation, but the work has since been resumed, and will be co
in a very short time. This will prove a valuable addition, and i
to be regretted that means are not available to extend it over t
cent portions of the canal. The work on the fence around the
has been suspended for want of funds; an appropriation for t
the inclosure is included among my estimates. As has been
stated, the pavement on the north front (the south side of Penn
avenue) should be regraded and repaved, as it is now much b
grade of the avenue. A pavement should also be laid along M

This garden, one of the most delightful features about Washington, and particularly to strangers, has become a great point of attraction; the many rare exotics, the great variety of our own climatic plants, and especially the handsome collection being made of the several varieties of the many species of trees which adorn our own native soil, will ever engage the attention of both the curious and the cultured.

The grounds directly to the west of this garden are intended for propagating different species of plants, shrubs, and trees, to be used in the embellishment of the different squares. Next adjoining is a reservation, upon which has been constructed during the war, and since, buildings for hospitals, and warehouses for public stores. Already several of these have been removed, and before long all of them will disappear, and it can then be laid out according to the plans originally adopted.

The Smithsonian grounds, or reservation No. 2, lie next in order as you proceed towards the west, and contain an area of 50 acres. Only one portion has been tastily arranged in accordance with the design of Mr. Downing, and a great deal of work remains to be executed before perfecting it. That part lying immediately south of the Smithsonian building has yet to be graded and drained, walks and drives to be spread out over its surface, and trees and shrubbery to be planted. An iron fence should be substituted for the wooden paling, and the walks regraveled; many other minor matters need attention. The fence on the north front, along the canal, should be replaced, as soon as practicable, by a new one.

Appropriations have been earnestly urged upon Congress, but scarcely a sufficient amount has been granted to keep even a proper watch over and for the preservation of such improvements both useful and ornamental, as have already been made. A magnificent institute of learning, and one disseminating practical knowledge far and wide, is certainly entitled to be surrounded by highly ornate works.

The grounds encompassing the Agricultural Department follow next in order, moving towards the west, and are situated between the Smithsonian and monumental reservations. The building is now entirely completed, save some few interior arrangements, and occupies a very commanding position. A fine view of the city and parts of the surrounding country, especially the river scenery, can be enjoyed from the different stories of the building, and from the top the eye can feast upon an extensive and almost uninterrupted panorama which is beautiful to gaze upon. The grounds, some 35 acres in extent, were, until recently, occupied by the department as an experimental garden, but are now being laid out into drives and walks, and ornamental plats for shrubs and flowers, and preparations are being made for establishing a magnificent arboretum. The report of the distinguished Commissioner of Agriculture will, no doubt, describe and illustrate at length the proposed plan of improvement. The drives and walks are being laid with the concrete pavement, a composition of tar, gravel, sand, and ashes. The only approaches to the building are at present by Twelfth and Fourteenth streets, although it stands south of the canal and directly in front of Thirteenth street. A splendid ornamental iron bridge should be made to span the canal in the prolongation of this street in order to communicate, through the large gateway which it is proposed to erect, with the broad avenue leading to the main entrance of the building; an estimate for a suitable bridge for carriages and pedestrians has been prepared and submitted. In speaking of the approaches to the two public reservations last referred to, it is impossible to refrain from calling the attention of the corporate authorities to the condition of the streets leading to the canal in front of them. Instead of being kept free

and open for the purposes of ventilation and health, they are obstructed in every possible way; the many persons frequenting the main avenue of the city are not able to catch even a stray glimpse of the green foliage of the trees, much less obtain a view of the buildings themselves; market stalls extend over the pavements, houses protrude beyond the building lines, piles of lumber block up the way, junk shops encroach upon the public grounds, rubbish is allowed to accumulate, and only within the last few weeks permits have been granted to erect stalls and shops on the prolongation of the center of one of the streets, which will entirely obscure the Smithsonian grounds from view. If my information is correct no private citizen has the right to permanently obstruct a street. The same remarks are applicable to the north and south sides of B, or Canal street, between Sixth and Thirteenth streets west. The small pittance of ground rent which would accrue to the corporation fund for granting privileges of the kind should not be allowed to interfere with the general health, the pleasure, and convenience of a large portion of the population of the city. Instead of these many obstacles being thrown in the way the streets should be kept open, and bridges built over the canal for the convenience of those who would seek recreation in the public grounds. The canal is a sufficient nuisance without adding to its nauseousness.

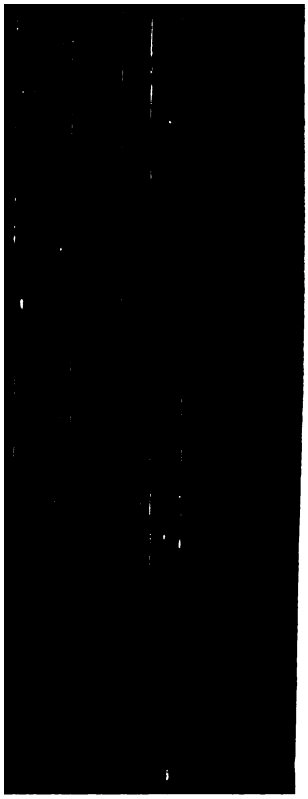
The Washington Monument reservation still remains in the same unimproved condition. The simple preservation of the fence inclosing it is all that has been done. The grounds are capable of very great adornment, and should not be allowed to present the dull, wide waste that they now do. The locality is particularly pleasing, and one from which a superb view of the Potomac can be had. The still incomplete shaft of the monument speaks more forcibly than words. Can it be possible that a nation boasting of its wealth, grandeur, and extended domain, will longer submit to the disgrace and dishonor of allowing this memorial to the greatest of our patriotic men to remain in its present unsightly, unfinished state? The Congress of the United States should not hesitate to make a liberal appropriation for perfecting it in all its details, at least in donating a sufficient sum as a nucleus about which the subscriptions of a generous people will amply cluster.

The grounds immediately around the President's house have received great attention, and offer to all a pleasant spot for recreation. Those directly south, towards the canal, and bounded on the east and west by Fifteenth and Seventeenth streets, should now receive the greatest embellishment. By the proposed plan for the improvement, which was adopted by the Secretary of the Treasury, the Supervising Architect of the Treasury Department, and the late Commissioner of Public Buildings, a new avenue will be opened for travel between the two last named streets, and an appropriation, for which an estimate is submitted, is earnestly recommended in order to complete the fences, with the necessary gates, along it. One is also added for fences to inclose the entire extent of the reservation. That splendid building, the Treasury Department, is now very nearly completed, and the various workshops connected with its extension will soon be removed. It is to be hoped that the comparatively small amount required for laying out and beautifying the adjacent grounds will be furnished. The magnitude of the work demands that a thorough and complete plan be adopted for the purpose of adorning them. The several reservations previously referred to comprise what is familiarly known as "the Mall," stretching from the Capitol to the left bank of the Potomac. Their dimensions are amply sufficient for a limited park for a large section of the city. As stated in my last annual report, "these grounds are unfortunately subdivided by sev-

eral transverse streets running north and south. Should they be made subterraneous, by tunneling, the different parts of the mall might be thrown into one, and thereby supply ample and uninterrupted space for walks and drives. As this may not be deemed practicable by many, owing to the level nature of the ground, and meet with great opposition in view of the expense, another plan is suggested to meet the present wants of the community. Let the whole extent of the reservation be laid out in continuous carriage ways, paths for equestrians, and walks for pedestrians, as if the different parts formed a unit. Gates with their lodges could be placed where the different communications intersect the streets, the crossings between them being handsomely paved. The keepers of these gates and grounds, selected from the many dependent and worthy soldiers and sailors who have been disabled during the war, by loss of an arm or leg, could, by some mechanical arrangement, while seated in their lodges, maneuver the gates, opening or closing them for the passer by." It was proposed during the last session of Congress to introduce a bill organizing a detachment or corps of watchmen from the wounded and disabled of the army to attend to the duties above enumerated. It was reported favorably upon by the House Committee on Public Buildings and Grounds. The channels of the river should be improved and a large quantity of land reclaimed, thereby extending the monumental grounds, and the mouth of the Tiber, or the basin of the canal, should be partially filled, also giving an increased number of acres; suspension bridges should also be thrown across the canal, uniting these grounds with those south of the President's mansion. By some such plan, beautiful and continuous drives can be had between the latter and the Capitol, free from all the noise and bustle and dust of the busy city. Regulations would have to be adopted to prevent heavily laden traffic from passing along the drives. One of the most charming spots for recreation, and one where the trees and shrubbery have been set out with so much taste and judgment, is Lafayette square; it has been made very beautiful, but, owing to the grounds being so level, the drainage is defective. The government has lately paid a very large proportionate part of the expense of constructing the sewer along the western front, and a system of underdrains leading into it could be adopted and the objection remedied. The walks have been graveled, and, considering the small force of gardeners allowed, the place has been kept in very good order.

Owing to the particular advantage of the locality Franklin square will, in the course of a few years, become one of the most splendid improvements in the city. The undulating character of the surface will always add a great charm to its appearance. A very marked change has already taken place in it, but a great deal more has to be done to render it what it is capable of becoming. A large number of trees of different species have been set out, and in course of time various kinds of shrubbery will be planted. The grounds have already been underdrained, and the paths substantially constructed. It is earnestly urged upon Congress to make an appropriation, an estimate being herewith submitted, for replacing the present dilapidated paling fence by a substantial and ornamental iron one, and also for the purpose of further improving the square. For the present fiscal year not one cent has been appropriated either for preserving it in its present condition or even for the pay of a watchman. An old revolutionary pensioner, and one of the oldest inhabitants in the city, has been temporarily detailed to stand guardian over this beautiful property.

The reservation known as Judiciary square calls for special attention.



the value of the adjoining property but also aid in developing the
nal plan of the city. There are a great many of these vacant
still unimproved, especially in that part of the city east of the c
As the corporation has been rapidly progressing in the march of im
ment by the opening and grading of streets, setting curbs, pavin
ters, and laying pavements, it would seem expedient for the gover
to keep pace with the progress being made. The two triangular
on Vermont avenue, between I and K streets, have been united, an
form one square, to which the name of Winfield Scott has been
It is proposed to make a corresponding square on Connecticut a
between the same streets, as soon as the frame buildings now occu
the public ground can be removed. It has been suggested by one
evening journals of the city that names be given to the different
gular reservations, and that they be selected from the list of the mo
tinguished poets and orators of the nation. It might probably be
in taste to call each after some one of the different species of
planted in them. The idea is a very excellent one and should be ad
for many reasons. It is also proposed to attach to each and ever
and shrub throughout the different grounds neat labels, containi
only the names by which they are familiarly known but also the b
cal one, for the information and education of those who frequent
for pleasure.

The citizens residing in the neighborhood of New Jersey av
between H and I streets, are very anxious that a reservation for
belonging to the government should be repurchased, and a square
lished for the benefit of that portion of the city. It is a very bea
and commanding site.

The attention of Congress is again respectfully called to the sele
of a site for a grand national park. By reference to my last a
report the subject will be found thoroughly discussed. That porti
the environs of the city known to all as the beautiful and romantic

d cabinets that minister to your tastes, that will not freely be sanc-
ıned by the people; for such in itself is the establishment of a nation's
iversity, whither all may come to wonder and to learn, and in which
may feel a rightful public pride. A public park should be inaugurated
at shall have no rival anywhere for beauty, or extent, or ornamen-
tion, as it will have none for the illustrious characters gathered from
whole continent in the after time to wisely rule our republic from this
nter of power. Let us profit by the accumulated experience of so many
ɛtropolitan cities, and so many great nations, and secure, while we
ay, here at the city of Washington, ample scope for a national park
ɔrthy of our people and our country."

In all the contemplated improvements of the public grounds of the
pital, one very ornamental, as well as sanitary, feature should not be
rgotten—the free introduction of water, as *jets d'eau*, fountains, minia-
re lakes, into each and all of them, will greatly enhance their charms
refreshing and cooling the heated atmosphere of summer, and by the
eservation in all their natural beauty of the various shrubs and trees
hich adorn them. The abundant supply furnished from the Great
alls of the Potomac, by the Washington aqueduct, will be a never-
iling source from which to obtain all that may be needed for such
ırposes. Groups of statuary should be artistically arranged throughout
e grounds as another evidence of enlightened taste.

AVENUES AND STREETS.

But very limited appropriations were made for the last fiscal year to be
pended upon the improvement of the avenues, 20 in number. Many
these have been either entirely or partially opened, and many are
ıite impassable. Forming the most direct lines of communication
ɛtween different and distant sections of the city, and between many of
e public buildings and grounds, it is necessary that the grades should
ɔ established at once, and that the roadways be placed in good travel-
g condition. This should be done in justice to the holders of property,
well as for the public convenience. Virginia avenue has been graded
ıd graveled for several squares, but work was suspended in conse-
ıence of no money having been appropriated to continue it. This is one
the finest streets in the city, and the advantages of opening it to travel
ıve already been experienced. The large amount of marketing brought
ɛr the Navy Yard bridge is now diverted from the old and long-fre-
ıented thoroughfare of Pennsylvania avenue, east of the Capitol, and
ıds more direct access to the different emporiums of trade. In the
ɛnt of the building of a more ornamental and permanent bridge across
e Eastern Branch, the terminus of this avenue may be probably selected
r the new site; the river is at that point of less breadth than at the
cality of the present pile one, and the avenue will make a grand
ɔproach. A great deal of the traffic will be directed from Benning's
ɛidge, and, in fact, one substantial structure will answer the purposes
the two existing ones.

Since the removal of the workshops used in the extension of the
ıpitol, New Jersey avenue, to the south of the building, presents an
ıproved appearance.

Maryland avenue, one of those most constantly used, leads northerly
the direction of Benning's bridge. Immediately in the vicinity of the
apitol it has been graded and graveled, but still a large amount of work
required to place it in good repair as far as the city limits. At times
is almost impassable. In that portion towards the Long bridge it
ɔnstantly needs *repairs*.

The impossibility at present of using Delaware avenue has already been noticed.

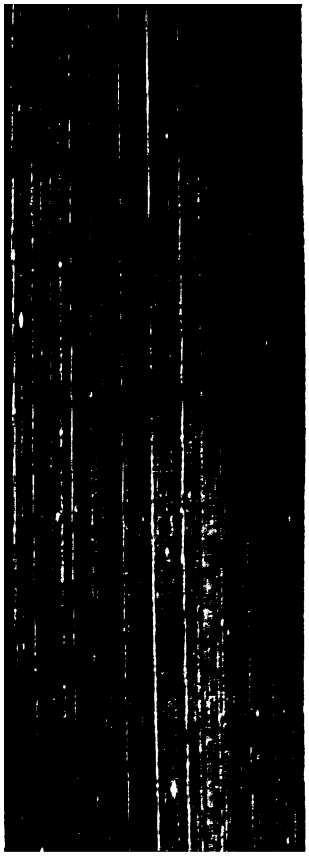
Vermont avenue is a fine broad one leading direct from the President's house to the environs of the city, and should be opened its entire length. Its position makes it one of the grandest streets of the city. Connecticut avenue starts from the same center, and is in a direct line to those beautiful grounds along Rock creek which have been selected for a national park. When opened and repaired throughout it will be one of the finest drives in the direction of that proposed public improvement. The reservations along it should be inclosed and adorned. An act to incorporate the Connecticut Avenue and Park Railway Company has already become a law.

New York avenue, to the west of the Navy Department, has been partially opened, and the corporation are now engaged in grading and paving north E street, leading from it along the front of the Observavatory grounds; this will very materially improve that part of the city.

Massachusetts avenue should be made one of the most magnificent ones in the metropolis. It extends from Boundary street, near the Paper Mill bridge across Rock creek, to the public grounds occupied by the government powder magazines, on the banks of the Eastern Branch, and is very nearly parallel to the main thoroughfare, Pennsylvania avenue. Some very little work was executed towards opening it, at several places, to the traveling public. For many years it had remained closed, houses, gardens, brick-kilns, and other obstructions preventing it from being used. It is one of the most direct lines of communication between a large section of the city of Washington and a great portion of Georgetown. To make it more perfect, some one of the streets, Dunbarton, Beale, or West street, in the latter city, should be opened to the banks of the creek, in the prolongation of either N, O, or P streets of the capital, the connection between them being formed by a substantial arched bridge. As the creek is not very wide, and the banks high, very heavy embankments would not be required to diminish the span over it. This would not only prove a great benefit to those residing in the immediate neighborhood, but would be an immeasurable advantage to all the citizens of both places. A considerable portion of the travel would be diverted from the Aqueduct bridge, uniting Pennsylvania avenue with Bridge street, and relieve that structure from being, as at present, the great highway for the heaviest traffic.

There are many other avenues that require attention on the part of the government; Boundary street, towards which many of them lead, forms a connecting link between them, and skirts the environs of the city. It is capable of great embellishment; by increasing the width and planting along it rows of shade trees, it will become a most delightful and much-frequented drive. The labor for a great amount of the work accomplished was paid out of the appropriation made by Congress to aid in supporting the indigent and poor of the city, and the plan succeeded most admirably; those who were destitute and deserving obtained work, and kept them from distress and want. Instead of appropriating money for their immediate care, save in extreme cases, it would perhaps be better policy to inaugurate improvements, so as to enable them to obtain labor and gain their own support. In my last annual report, to which reference is again made, it was stated that the oldest and greatest thoroughfare from one limit of the capital to the opposite one, connecting the most important buildings and grounds, is Pennsylvania avenue; a glance at the map shows that it is the most central one. In consideration of the great importance of this avenue, the relative position it bears to all

ıe avenues and streets, which either diverge from it in every direction
· intersect it along its entire length, some most marked improvements
ıould be inaugurated to render it as great and beautiful in appearance
; it has proved to be necessary and accessible. The very limited
›propriations of the last fiscal year enabled me to make only such
pairs as were most needed; some sections had become almost impas-
ble from the effects of weather, and from having been badly cut up by
ıe immense amount of travel over them. It is now only in tolerable
›ndition. Congress failed to make any appropriation at all for keeping
is avenue in order during the present fiscal year; from the charity
nd previously referred to a force was employed to give it one thorough
eaning, and since then the services of one man, with a horse, cart, and
'iver, is all the labor employed to keep it in a somewhat cleanly state;
: not only has to sweep the roadway and repair the holes along it, but
so to clean the sewer traps. Is it to be marveled, then, that its condi-
›n is no better? The seat of government of a nation should be able to
›ast of one magnificent avenue, at least; that part extending from Rock
eek, its terminus on the west, to that splendid pile of architecture,
e Capitol, should receive the advantages of the most improved roadway.
ıere is scarcely a street or avenue in the city over which one can drive
ith ease and comfort; it is only lately that the bluestone pavement has
'en laid to any extent, and the agreeable contrast experienced between
and that of the old-fashioned cobblestone cannot but be appreciated
· all. The streets of the city are public property, in which all citizens
e more or less interested, and in point of necessity no other public
›rk can equal them. Why, then, is not more attention paid to paving
ıd ornamenting them? In view of the importance of having at least
ıe good pavement traversing the city, the recommendation is made
at the present one be removed, and that the avenue be laid with either
ıe or the other improved ones now coming into general use. If stone
to be used, the Belgian pavement possesses the greatest advantage;
ıt should one of wood be preferred, which is delightful, easy, and not
›isy, either the Nicolson, Ream, Fayette, Stafford, or Stowe will prove
be as near perfection as it is possible to construct them. Then, again,
e asphaltum, the concrete, and other similar ones have their advantages.
ıese should all be subjected to the severest competitive examinations.
ıe length of that part of the avenue which it is proposed to improve
over two and a half miles, and averaging in superficial measurement
›out 150,000 square yards. Although the nation at large is deeply
terested in the general improvement of the metropolis of the republic,
d especially in the accomplishment of such a great and much-needed
›rk, still the property-holders along the avenue, as well as the citizens
nerally, are mostly benefited by it; the expense might, therefore, be
uitably proportioned between the municipal and general governments.
any citizens have petitioned Congress to pave Louisiana and Indiana
'enues, leading to the railroad depot from Pennsylvania avenue. In
dition to laying a good carriage-way, other advantageous changes
ight be introduced for the beautifying of the broad avenues and
reets. Some sketches exhibiting different plans of improvement and
ornment, one or two of them taken from those employed in several of
e large cities of Europe, will accompany this report, and give an idea
what can be done in the way of ornamentation. By an act making
›propriations and to supply deficiencies in the appropriations, approved
ly 25, 1868, it was provided "that section 15 of an act entitled 'An
t to incorporate the city of Washington,' passed May 15, 1820, and
ction three of an act approved May 5, 1864, entitled 'An act to amend



ate part. Before closing the subject of avenues and streets your
tion is respectfully called to the improvements suggested by the
pletion of the north wing of the Treasury Department. It is
regretted that the site of that building is so low, and that in conseq
the fine effect of the elegant front on the north is considerably imp
It has been recommended by the supervising architect, in order to
come the difficulty of situation, that either a strip of land of 61 f
width on the east side of Fifteenth street, between New York and Pe
vania avenues, be condemned, and the street removed a correspo
distance from the building, or that the grades of Fifteenth street an
portion of the avenue on the north, between Fifteenth street and the
of the President's house, be reduced. The surroundings of this
nificent building should be as extensive and beautiful as possibl
the expense of rendering them so will be small in comparison wi
cost of its construction. Similar remarks are applicable to the s
encompassing the Patent Office building and the Post Office D
ment. Seventh street should receive a gradual and easy grade be
the northeast angle of the first named building and Pennsyl
avenue, and the grade of F street, lying between the two, be ma
correspond between Ninth and Sixth streets, and also that of E
between F and the avenue. At present the buildings are scarcel
ble from this main thoroughfare. Other improvements are neede
a description of the details would require too much space.

WASHINGTON CANAL.

Since the date of my last report this canal has remained in the
if not reduced to a still more filthy, pestilent condition; no effort
been made by either the government or the corporation to bet
What was then written is still applicable; it is a great nuisance
present state, and extremely disgusting to both sight and smell.
nothing more than an open sewer, constantly generating noxious
which are most deleterious to those not only residing immediately
its banks, but to the inhabitants of the entire city. Let it be

TIBER CREEK.

This creek, with its branches, drains a very considerable extent of land without the city limits as well as a large part of the city itself. A great accumulation of sand, gravel, and many very deleterious substances are washed down and deposited in the bed of the stream. Some action should be taken to arch it over from where it crosses Pennsylvania avenue to the extreme northern limits of the corporation. In addition, some system of gravel pits and drains, for collecting the washings of the soil, should be arranged at different points; if not arched over the banks should be protected by sodding or masonry. The management of the Tiber must be treated in the light of a main sewer for a large and growing section of the city, and all improvements projected with that object in view. A bill has been introduced into Congress to arch over the creek. During the last session a small appropriation was made for an arched roadway to cross it on North Capitol street, provided the corporation will furnish the balance of the amount necessary to build it.

MARKETS.

Attention is again called to the condition of the Center market, on Pennsylvania avenue; the dilapidated and unsightly buildings not only still exist, but additions are being made to them; new stalls are being constructed across Eighth street, entirely obstructing it, and altogether shutting out the view of the Smithsonian grounds. A joint resolution of Congress, approved January 30, 1864, prevents the erection of any permanent building upon any property reserved to, or for the use of, the United States, and an injunction was issued to stop work upon a structure then going up for market purposes. A bill was introduced into the Senate, and passed by that body at its last session, providing for the removal of the Center market, and for the erection of a market building in a more suitable locality. Strong opposition was made to the passage of the bill in the House by those interested in retaining it on its present site. It is not only a reflection upon the good taste of the community that such an old and objectionable structure should be allowed to stand upon the principal avenue of the capital, but it is a disgrace to see this main artery, connecting the Capitol with most of the public buildings, obstructed by such a diversified and by no means pleasing collection of commodities as are usually offered for sale on every market day. Cannot a more suitable locality be found, and one equally convenient of access? And cannot an ornamental as well as a commodious market be erected, which will be a credit to the city? If the corporation does not take the necessary steps to remove the cause of this great nuisance by erecting a suitable and imposing structure, the government should resume control of the reservation for the purpose of improvement.

POTOMAC RIVER FRONT.

Several applications have been made for permits to construct wharves along the river front. It seems a disputed point whether the government, the corporation, or the heirs and assignees of the original proprietors of the land upon which the city stands, have the right to grant or sell the privilege. A legal decision should be had in the case, as it is a most important question, and, in the event of any permanent improvements being made to the city channel, will become more so. A bill has been introduced in the Senate to incorporate the Potomac Navigation

and Transportation Company of the District of Columbia, in which it is to be enacted that the corporation is authorized to purchase and hold lands, and may locate and construct wharves, docks, and railways into the Potomac river and in front of Mason's island, so as not to interfere with the navigation of the river. As such important operations are contemplated, it is necessary that all questions of law be settled.

PUBLIC BUILDINGS.

The extension of the Capitol and the repairs of the center building, and also the completion of the Patent Office building, are under the charge of the architect, Mr. Edward Clark; the General Post Office building is under the control of the disbursing clerk of the department, Mr. E. B. Olmstead; the Treasury extension is being built under the superintendence of the supervising architect of the Treasury Department, Mr. A. B. Mullett; the War and Navy buildings, and the building at the corner of F and Seventeenth streets, are in the care of some one of the officials attached to one or the other of the departments or bureaus. There is a very great number of private buildings rented for government purposes.

PRESIDENT'S HOUSE.

Several very important renovations and repairs were attended to during the last fiscal year, and the main building and stables are now in very good order. A few rooms still require to be painted and papered, and some of the furniture and carpeting to be renewed. The exterior walls and colonnades require to be repainted. The conservatory attached to it has been almost entirely rebuilt, and plants are being purchased to replace those destroyed by fire. The small appropriation for this building is entirely inadequate to keep it in as complete order as it should be, and to preserve and supply all the needful appendages to a mansion intended for the residence of the Chief Magistrate of the nation. A larger appropriation is asked for annual repairs for the next fiscal year, and also one for refurnishing the establishment at the commencement of the next presidential term. As this city has become the permanent seat of the government, where millions have been expended upon the public buildings and the improvement and ornamentation of the grounds, it would seem proper that each State should build and furnish suitable houses for its senators and representatives. The necessary appropriations could easily be made, and would prove not to be bad investments. Those benefited would be made more comfortable, and be able to receive and entertain their constituents and friends; the city would be improved by the addition of highly embellished houses, and more apparent stability would be given to the capital. Foreign nations would be induced to emulate the example, as it would then appear that each State individually had some permanent and active interest and influence over the municipal affairs of the city. Attention is again called to my last annual report in reference to the selection of a site for a new Presidential Mansion.

WASHINGTON AQUEDUCT.

The annual report, which is herewith appended, of the superintending engineer of the Washington aqueduct, furnishes in detail a statement of the operations on that work during the last fiscal year. The foundation and superstructure masonry of the dam at the Great Falls of the Potomac were completed, and the gate-house at the same place is nearly finished.

The stone bridges are still left in the same incomplete condition; there being no parapets or railings to them, it is considered very dangerous to cross them. The conduit extending from the gate-house at the Great Falls to the distributing reservoir has been in very good order, considering that the road over it has become a great highway for the farmers living along the line of it; many country roads also lead into it. As it has become in such general use it should be macadamized; the soil, being of clay, is easily cut through in wet weather to the crown of the arch. Since the completion of the connecting conduit around the receiving reservoir the supply of water comes direct from the Potomac without mingling with that of any other stream; the reservoir is now used only for the storage of water to meet any emergency that may arise.

The distributing reservoir should be deepened as soon as possible to enable the water to settle before reaching the city, and to enable it to hold a larger quantity in store in the event of accidents. The embankments have been greatly damaged by the washing of the waves caused by high winds, and should be repaired without delay, and lined with stone laid in cement. The high service reservoir is still left in an incomplete state. It would be a great improvement to remove the unfinished dome intended to cover it, and inclose it by a neat iron railing. It was built in order to furnish a supply of water to Georgetown heights, a part of the city too high to be served direct from the main pipes; the water is forced into it by a Worthington water-pressure engine, located in the west abutment of the aqueduct bridge across Rock creek. There has been constant complaint that the residents on the heights are not sufficiently supplied with water, but from a thorough examination and trial it is evident that there is more than enough for all practical purposes, and that the consumption, nearly 200,000 gallons, being forced up daily, must be attributed to wastefulness. The adoption of meters in all dwellings and mills is recommended by the engineer. The iron bridges have recently been painted and repaired in every particular, and are in excellent order. The pipe line, which is a continuation of the conduit, extends from the distributing reservoir to the navy yard; it has required very little repair. It is again earnestly recommended that new fire-plugs should replace the old ones on Pennsylvania avenue, and that they be connected directly with the 12-inch main along it. At present the steam-engines have to obtain their supply from other streets. The cost of erecting new ones will be very small. Considering that there are but few thoroughly fire-proof buildings belonging to the government, that millions of dollars of public property are distributed throughout the city, and that immensely valuable papers are stowed away in most unsafe offices, every precaution should be taken to prevent their destruction. My attention has been frequently called to this matter. The archives belonging to the War Department, especially to the Adjutant General's and Paymaster General's offices, are particularly valuable, and in their safety and preservation almost every family in the land is interested. The pipes for increasing the supply of water in the Capitol building were laid last year, and work has been commenced in placing others along north B street and First street east, which will make complete the connection between the terminus of the 30-inch main on New Jersey avenue with the 12-inch main on Capitol hill. This will partly remedy the deficiency of water in the eastern portion of the city. To meet the demands of the constantly increasing growth of the northern part of the city another large main will have to be introduced into that section from the distributing reservoir. The engineer reports that the supply of water has been uninterrupted, and the consumption has exceeded 12,000,000 of gallons

per day, a large amount of which has been expended by the government buildings, workshops, and fountains. As stated in my last report, certain tracts of land are occupied by the government for aqueduct purposes, for which, in some cases, only nominal rents are paid; in others no rents have been paid at all, and claims are now being made by the owners to become either repossessed of their property or to be paid for its use. As the United States must retain the few acres for the benefit of this national work, it is earnestly urged that the necessary appropriations be made to purchase them. But a few thousand dollars is needed to meet all the claims and to buy the land. The great importance of introducing into the capital an unlimited supply of pure and wholesome water cannot be overestimated. The water thus furnished has become a great motive power at the different government workshops and buildings throughout the city, and when the capital of the nation becomes what every enlightened citizen desires to see it, a still larger demand will be made for both useful and ornamental purposes. Including the estimates submitted for completing the Washington aqueduct, the total cost of the work will not exceed $4,000,000. The following tables show some very interesting data in regard to what should be considered the greatest improvement for the benefit of the city of Washington.

Table of distances by the aqueduct from gate-house at Great Falls to navy yard and intermediate points.

	From Great Falls.	From navy yard.	Intermediate points.		From Great Falls.	From navy yard.	Intermediate points.
	Miles.	*Miles.*	*Miles.*		*Miles.*	*Miles.*	*Miles.*
Great Falls gate-house	.....	18.59	.....	Wooden bridge rec'g res'r	9.40	9.19	0.33
Waste weir No. 1	0.36	18.23	0.36	Gate-house rec'g reservoir.	9.79	8.89	0.30
Over-fall No. 1	0.59	18.00	0.23	Waste weir No. 3	11.11	7.44	1.45
Bridge No. 1	1.27	17.32	0.68	Influent gate-house	11.56	7.03	0.41
Bridge No. 2	1.46	17.13	0.19	Pipe-vault distributing reservoir.	12.02	6.57	0.46
Junction road	1.94	16.65	0.48				
Road at Radcliffe's	3.22	15.37	1.28	Foundery branch	12.65	5.94	0.63
Culvert No. 12	4.32	14.27	1.10	College Pond bridge	12.91	5.68	0.26
Bridge No. 3	5.00	13.59	0.68	Rock Creek bridge	13.94	4.65	1.03
Bridge No. 4	6.26	12.33	1.26	East front of Capitol	16.81	1.78	2.87
Brook's road	8.85	9.74	2.59	Navy yard	18.59	.....	1.78

Number and length of tunnels.		Grades.	
	Feet.		*Feet.*
Tunnel No. 1	1,438	Feeder entrance	146.80
Tunnel No. 2	3,865	Manhole 11, near junction	145.10
Tunnel No. 3	86	Bridge No. 3	142.50
Tunnel No. 4	766	Bridge No. 4	141.50
Tunnel No. 5	90	Guard-gate	139.20
Tunnel No. 6	88	Invert	138.00
Tunnel No. 7	679.5	Crown intrados	143.00
Tunnel No. 8	421.9	Effluent receiving reservoir	137.50
Tunnel No. 9	725	Influent distributing reservoir	137.30
Tunnel No. 10	86		
Tunnel No. 11	626	Descent, 9¼ inches per mile.	
Tunnel No. 12, Dalecarlia	800	Diameter of conduit, 9 feet.	

Number and span of bridges.		Cost of stone bridges.	
Bridge No. 1	14 feet cut stone.	Bridge No. 1	$4,006
Bridge No. 2	10 feet cut stone.	Bridge No. 2	7,779
Bridge No. 3	75 feet cut stone.	Bridge No. 3	76,068
Bridge No. 4	220 feet cut stone.	Bridge No. 4	237,000
Bridge No. 5	120 feet iron pipes.		
Bridge No. 6	200 feet iron pipes.		

Area of reservoirs.		Pipe and culverts.	
Receiving reservoir	53 acres.	Length of pipe-line	18 miles.
Distributing reservoir	44 acres.	Number of culverts	26
High-service reservoir	120 feet diameter.		

As an inducement to obtain experienced and reliable persons, compensation commensurate with their services should be afforded them. The pay of the clerk, whose duties are very arduous, should be certainly increased. The assistants on the different works connected with the Office of Public Buildings, Grounds, and Works, all deserve great credit for the manner in which they have severally performed their duties and carried out my instructions.

I am, general, very respectfully, your obedient servant,

N. MICHLER,
Major of Engineers, Bvt. Brig. Gen. U. S. A.

Brevet Major General A. A. HUMPHREYS,
Chief of Engineers United States Army,
Headquarters Corps of Engineers, Washington, D. C.

V 1.

OFFICE OF THE WASHINGTON AQUEDUCT,
Washington, D. C., October 1, 1868.

GENERAL: I have the honor to submit the annual report of the operations of this office for the year ending September 30, 1868, arranged under the different heads that were adopted in the last annual report, as follows:

POTOMAC DAM.

The foundation and superstructure masonry and the back filling of this structure from the Maryland shore to Conn's island were fully finished by the beginning of last December, to a height of 147 feet above the datum line of the Washington aqueduct, affording during the lowest stages of water in the river a depth of five feet at the head of the conduit. A thorough examination recently made of the masonry shows that it has not sustained any damage by the freshets of the Potomac, which last spring were unusually heavy. The large dead tree left by the flood on the bulk-head on Conn's island shows that the water was over 10 feet deep on the crown of the dam.

The pond above the dam extends to the upper end of Conn's island; it contains a great many rocks, trees and bushes which should be removed, as the roots, branches, and leaves decay and affect the purity of the water.

The temporary dam was nearly all washed away; it had been kept in repair since 1863, and was a constant source of trouble and expense. It is gratifying to be able to report that it can now be dispensed with.

GATE-HOUSE AT GREAT FALLS.

This building is nearly completed; the roof is ready for the slates, and arrangements are being made for removing the decayed wooden floor and the timbers that support the gates, and replacing the same with flooring and girders of cast iron.

BRIDGES.

The stone bridges are all in an unfinished condition; the importance of completing them has been fully represented in preceding reports, but, owing to the failure of Congress to make an appropriation for that purpose, no work has been done upon either of them since 1863.

THE CONDUIT.

The conduit, extending from the gate-house at Great Falls to the distributing reservoir, is generally in good condition. An unusually large amount of work has been done on the embankments, ditches, culverts, &c., which has been made necessary by the heavy rains that have fallen during the year; to a certain extent similar work will have to be done every year. The road over the conduit has become one of the principal highways of Montgomery county, and is extensively used by the farmers for bringing their produce to market; it should be all macadamized, for during wet weather, owing to the large amount of travel over it, it is difficult to keep it in good order.

The connecting conduit has been in constant use since August, 1867; the heavy rains which have fallen during the year, together with the freshets in Powder Mill Branch, damaged the slopes of the embankments; it is now in good condition; the slopes facing the reservoir should be protected with ripraps. Since August, 1867, the receiving reservoir has been used only for the storage of water, the water from the Potomac passing by it through the connecting conduit to the distributing reservoir.

DISTRIBUTING RESERVOIR.

The condition of this reservoir is similar to what it was at the date of the last annual report; only the embankments have been further damaged by the waves. The slope of the southeast embankment, originally built with two feet of base to each foot in height, is now perpendicular. In my opinion the water should be drawn off, and the reservoir not used again until it is completed. The necessity of deepening and finishing the distributing reservoir has been fully shown in preceding reports; especially in the supplemental report dated February 22, 1864, to which I respectfully refer.

HIGH-SERVICE RESERVOIR.

No appropriation was made for finishing this reservoir; consequently it is in the same condition that it was at the date of the last annual report. It has been in constant use for supplying that part of Georgetown heights which is too high to be supplied by the distributing reservoir. The water is forced into it by the Worthington water-pressure engine located in the west abutment of bridge No. 6. This engine has been in almost perpetual motion during the year; it has been stopped but a few times for repairs, and has forced to the heights over 190,000 gallons of water daily. This amount has not been sufficient for the inhabitants of the heights, and the supply stored in the high-service reservoir has been materially reduced.

On the first of May the surface of the water was 218 feet above datum; to-day it is only 208 feet.

I am convinced that much of the consumption is to be attributed to wastefulness, which might be prevented by attaching a meter to the pipes in each house where the water is taken, at the expense of the occupants, and a water rate established by the Georgetown water board. The consumption would then be reduced, and the supply would be abundant for all.

IRON BRIDGES.

The iron bridges are in good condition. New sidewalks have been built on Rock Creek bridge, and the masonry of the abutments has been repointed with cement. The floor will probably last for another year.

PIPE LINE.

The pipe line extending from the distributing reservoir to the navy yard is in good condition. During the year very few leaks have occurred; the water has been shut off only to make additional connections. Last year a 20-inch main was laid in North B street from the terminus of the 30-inch main to Delaware avenue, and a 12-inch main from this point to the eastern front of the Capitol. The 20-inch main is being continued in North B street to First street east, where it will be connected by a 12-inch main with the 12-inch main in A street north. The pipes are all delivered, and the work will be finished in a few weeks.

CONSUMPTION OF WATER.

The supply of water has been uninterrupted, and the consumption has exceeded twelve millions of gallons per day, a large amount of which has been consumed by the government buildings, fountains, and navy yard.

LANDS.

The following described parcels of land, to which the United States have no title, are occupied for the use of the Washington aqueduct:

At Great Falls, $5\frac{44}{100}$ acres of land belonging to the estate of the late Hall Neilson. In Montgomery county, the road across the farms of Jackson, Collins, and Anderson, and the road across the farm of William Brooke. In Georgetown, at the high-service reservoir, a lot of land fronting on High street and partly covered by the reservoir embankment, the property of Mrs. E. M. Mosher. In Georgetown, at bridge No. 6, a lot of land fronting on Montgomery street; on it are located the office, pipe yard, and workshops of the Washington aqueduct. This lot is the property of Mrs. Maria C. French, and has been occupied by the United States over eight years; no rent has been paid for the use of it; the taxes have been paid by Mrs. French, and this year they amount to $150. An appropriation should be made for the rent and purchase of each of the above-described parcels of land, as they will always be required for the use of the aqueduct.

FINANCIAL STATEMENT.

At the date of the last annual report the balance in the treasury applicable to this work was	$23,544 56
Appropriated by Congress, July, 1868, for deficiency in construction of the connecting conduit, Potomac dam, gate-house at Great Falls, and temporary dam	21,500 00

Appropriated by Congress, July, 1868, for salary of assistant engineer, superintendence and repairs for the year ending June 30, 1869	$25,000 00
Received from corporation of Georgetown for expenses incurred in supplying high-service reservoir with water during repairs to engine at bridge No. 6	137 00
	76,181 56

The expenditures to date are as follows:

For construction of connecting conduit	$23,558 38
For construction of Potomac dam	2,963 61
For construction of gate-house at Great Falls	1,627 29
For engineering, superintendence, and repairs	15,608 31
For office expenses, internal revenue, gas, fuel, and stationery	316 18
Balance	32,077 88
Total	76,181 56

Summary of appropriations made by Congress for the Washington aqueduct.

April 30, 1852	$5,000 00
March 3, 1853	100,000 00
March 3, 1855	250,000 00
August 18, 1856	250,000 00
March 3, 1857	1,000,000 00
June 12, 1858	800,000 00
June 25, 1860	500,000 00
July 4, 1864	150,000 00
July 28, 1866	142,584 00
December 20, 1866	12,000 00
March 2, 1867	20,000 00
July, 1868	52,500 00
Total	3,281,584 00

Estimate of the cost of completing the Washington aqueduct.

For rent and purchase of $5\frac{44}{100}$ acres of land at Great Falls	$1,320 00
For purchase of roadway from Great Falls to conduit road, $2\frac{3}{10}$ miles—$18\frac{4}{10}$ acres	1,012 00
For purchase of roadway across land owned by William Brooke	550 00
For rent and purchase of land at high-service reservoir	3,300 00
For rent and purchase of land at bridge No. 6	2,640 00
For excavating rocks and removing trees and bushes above dam at Great Falls	5,500 00
For lining and repairing tunnel No. 1	1,650 00
For completing stone bridges	27,500 00
For increasing embankment over conduit and macadamizing roads	11,000 00
For lining 350 feet of connecting conduit tunnel	15,400 00
For excavating the bottom of the distributing reservoir to an additional depth of 13 feet, and lining the interior slopes with rubble masonary laid in cement	411,115 00
For completing gate-houses at distributing reservoir	44,538 00
For 30-inch pipe from distributing reservoir pipe vault to Foundery Branch pipe vault	78,633 00
For completing high-service reservoir	8,800 00
For riprapping water face of connecting conduit	11,000 00
For ventilators over conduit	3,080 00
For fencing conduit and reservoirs	21,000 00
For building office at bridge No. 6	3,300 00
For engineering, superintendence, and repairs for the year ending June 30, 1870	33,000 00
	685,338 00
If to the above be added the amount of former appropriations	3,281,584 00
The total will be	3,966,922 00

I am, general, very respectfully, your obedient servant,

THEODORE B. SAMO,
Chief Engineer.

Brevet Brigadier General N. MICHLER,
Major of Engineers U. S. Army, in charge.

V 2.

Estimate of amount required to be appropriated for public buildings, grounds, and works, and for continuing the construction of the Washington aqueduct, and for supervision and repair of the existing portion of the same, under direction of the Chief Engineer of the army, for the fiscal year commencing July 1, 1869, and ending June 30, 1870.

Head or title of appropriation.	Reference to law by which last appropriation was made.				Estimate of appropriation required for the fiscal year ending June 30, 1870.	Estimate of balances of appropriations unexpended on the 30th of June, 1869, which may be applied to service of next fiscal year.	Appropriations for the fiscal year ending on the 30th of June, 1869.
	Date.	Vol.	Page.	Sec.			
For repairs, care, and improvements of public buildings and grounds, per estimate in detail herewith, marked A.	.....	.....	.....	.....	.....	.....	$526,000 00
For compensation of persons employed in and about the public buildings and grounds, per statement in detail herewith, marked B.	.....	.....	.....	.....	.....	.....	51,430 00
For continuing the construction of the Washington aqueduct, and for the supervision and repair of the existing portions of the same, per estimate in detail herewith, marked C.	.....	.....	.....	.....	.....	.....	685,338 00
For improvement of the Virginia or Georgetown and Washington channels of the Potomac river, in the District of Columbia, per statement in detail herewith, marked D.	.....	.....	.....	.....	.....	.....	138,000 00
Total	.....	.....	.....	.....	.....	.....	1,400,768 00

A.—*Statement in detail of amount required for repairs and improvements of the public buildings and grounds at Washington city, D. C., under the direction of the Chief Engineer of the army.*

Object of appropriation.	Reference to laws by which the last appropriation was made.				Am't required to be appropriated.
	Date.	Vol.	Page.	Sec.	
For casual repairs of the navy yard and upper bridges	July 20, 1868	Pam.	8	.....	$5,000 00
For repairs and taking care of the bridge at or near the Little Falls of the Potomac river	July 20, 1868	Pam.	8	.....	2,000 00
For repairs of the Long bridge across the Potomac river	July 20, 1868	Pam.	8	.....	5,000 00
For fuel for the President's house	July 20, 1868	Pam.	8	.....	5,000 00
For repairs of Pennsylvania avenue, including cleaning and repairing sewer traps, new crossings, &c	Mar. 2, 1867	Pam.	462	1	20,000 00
For improvement and taking care of public reservation No. 2 and Lafayette square	July 20, 1868	Pam.	8	.....	10,000 00
For taking care of and improving grounds south of the President's house	July 20, 1868	Pam.	8	.....	10,000 00
For removing snow and ice from pavements and public walks	July 20, 1868	Pam.	8	.....	1,000 00
For repair of water-pipes and replacing fire-plugs along Pennsylvania avenue	July 20, 1868	Pam.	8	.....	10,000 00
For manure and cartage for the same, for the public grounds and reservations	July 20, 1868	Pam.	8	.....	3,000 00
For further improvement and care of reservations on New York, Pennsylvania, Massachusetts, Connecticut, Vermont, and Maryland avenues	July 20, 1868	Pam.	8	.....	15,000 00
For painting iron fences around the public squares and reservations	July 20, 1868	Pam.	8	.....	3,000 00
For annual repairs of the President's house	July 20, 1868	Pam.	8	.....	10,000 00
For flower-pots, glasses, twine, &c	July 20, 1868	Pam.	8	.....	1,000 00
For fuel for the center building of the Capitol	July 20, 1868	Pam.	8	.....	1,500 00
For continuing the grading of Virginia avenue	Mar. 2, 1867	Pam.	463	1	20,000 00
For completing the iron fence around the botanic garden and adjoining avenues	July 28, 1866	Pam.	314	1	29,000 00
For completing the improvement of Franklin square by inclosing it with an iron fence, planting trees, shrubbery, &c.	July 28, 1866	Pam.	315	1	25,000 00

A.—*Statement in detail of amount required for repairs and improvements of the public buildings and grounds, &c.*—Continued.

Object of appropriation.	Reference to laws by which the last appropriation was made.				Amt required for the appro-
	Date.	Vol.	Page.	Sec.	
For the further improvement of Lincoln square	July 25, 1866	Pam.	251	1	$10,0
For hire of carts on public grounds	Mar. 2, 1867	Pam.	462	1	3,0
For purchase and repair of tools used on the public grounds	Mar. 2, 1867	Pam.	462	1	1,5
For purchase of trees and tree-boxes, to whitewash tree-boxes, and repair pavements in front of reservations	Mar. 2, 1867	Pam.	462	1	5,0
For lighting the Capitol, President's house, and public grounds, the executive offices, &c	July 20, 1868	Pam.	8	.....	40,0
For pay of lamp-lighters, plumbing, gas-fitting, repairs, and cleaning, and material of all kinds	July 20, 1868	Pam.	8	.....	10,0
For purchase of stationery, books, maps, plans, office furniture, and contingents of the office	July 20, 1868	Pam.	8	.....	2,0
For completing iron fencing of the President's grounds on the south, and along the avenue now being opened between Fifteenth and Seventeenth streets, including gates, &c	.....	.....	.....	.....	27,0
For iron fencing of grounds south of the President's house along Fifteenth and Seventeenth streets to the canal, and along the canal, north side, between said streets, including gates, &c	.....	.....	.....	.....	40,0
For refurnishing the President's house at the commencement of the next presidential term	.....	.....	.....	.....	25,0
For improving Massachusetts, Connecticut, New York, Maryland, Delaware, and New Jersey avenues	.....	.....	.....	.....	50,0
For expenses to be incurred in the improvement of streets, avenues, and alleys in the city of Washington, passing by or through the property of the United States, and abating nuisances, to be expended under the Chief of Engineers	.....	.....	.....	.....	100,0
For an iron bridge across the canal at Sixth street west, 81 feet in length	.....	.....	.....	.....	10,0
For an iron bridge at Thirteenth st. west across the canal, leading to the Agricultural Department, having a span of 150 ft	.....	.....	.....	.....	20,0
For improvement, care, protection, and repair of seats, fountains, &c., in the Capitol grounds, &c	.....	.....	.....	.....	2,0
For improvement of the monumental reservation about the Washington statue	.....	.....	.....	.....	5,
Total	.....	.....	.....	.....	326,

B.—*Statement in detail of compensation authorized by law to persons employed on the buildings and grounds, under the direction of the Chief Engineer of the army.*

Designation of the office.	Reference to laws by which the compensation was authorized.				
	Date.	Vol.	Page	Sec.	
Clerk in office of public buildings	Aug. 31, 1852	10	91	1	$1,
Messenger in office of public buildings	Mar. 3, 1859	11	421	1	1,
Public gardener	Mar. 3, 1851	9	612	1	1,
Laborer in charge of water-closets in the Capitol	Mar. 2, 1867	Pam	456	1	
Foreman in public grounds	Feb. 25, 1863	12	694	1	1,
Twenty-one laborers in public grounds, at $864 per annum	Mar. 3, 1851	9	613	1	18
Four laborers in the Capitol, at $720 per annum	Mar. 3, 1863	12	759	4	2
Furnace keeper in the old hall of the House of Representatives	Feb. 25, 1863	12	694	1	
Furnace keeper in the President's house	Aug. 18, 1856	11	117	1	
Two policemen at the President's house	Mar. 2, 1867	Pam	456	1	2
Two watchmen at the President's house	Mar. 2, 1867	Pam	456	1	1
Doorkeeper at the President's house	Aug 31, 1852	10	91	1	1
Assistant doorkeeper at the President's house	Aug. 31, 1852	10	91	1	
Two draw-keepers at bridge across the Eastern Branch, fuel, oil, &c	Aug. 31, 1852	10	92	1	1
Watchmen at Franklin square	Feb. 28, 1866	Pam	315	1	
Person to take charge of heating apparatus for the Library of Congress	Mar. 2, 1867	Pam	456	1	1
Electrician for the Capitol	Mar. 2, 1867	Pam	463	1	1
Five watchmen at public reservation No. 2	Mar. 2, 1867	Pam	456	1	5
Eight draw-keepers at Long bridge, fuel, oil, &c	Mar. 2, 1867	Pam	456	1	7
Total	.....	.....	.....	.....	51

C.—*Estimate in detail of the cost of completing the Washington aqueduct, and for the supervision and repair of the existing portions of the same, for the fiscal year ending June* 30, 1870.

Object of the appropriation.	Reference to laws by which the appropriation was made.				Amount required to be appropriated.
	Date.	Vol.	Page.	Sec.	
For rent and purchase of 5.44 acres of land at Great Falls					$1,320 00
For purchase of roadway from Great Falls to conduit, 18.4 acres					1,012 00
For purchase of roadway across land owned by Wm. Brooke					550 00
For rent and purchase of land at high-service reservoir					3,300 00
For rent and purchase of land at bridge No. 6					2,640 00
For excavating rocks, trees, and bushes above dam at Great Falls					5,500 00
For lining and repairing tunnel No. 1					1,650 00
For completing stone bridges					27,500 00
For increasing embankment over conduit, and macadamizing roads					11,000 00
For lining 350 feet of connecting conduit tunnel					15,400 00
For riprapping water face of connecting conduit embankment					11,000 00
For excavating the bottom of the distributing reservoir to an additional depth of 13 feet, and lining the interior slopes with rubble masonry laid in cement					111,115 00
For completing gate-house at distributing reservoir					44,538 00
For completing high-service reservoir					8,800 00
For ventilators over conduit					3,080 00
For fencing conduit and reservoirs					22,000 00
For 30-inch pipe from distributing reservoir pipe vault to Foundry Branch pipe vault					78,633 00
For building office at bridge No. 6					3,300 00
For engineering, superintendence, and repairs for the year ending June 30, 1870	July 25, 1868	Pam.	4		33,000 00
Total					685,338 00

D.—*Statement in detail of the cost of improving the Virginia, or Georgetown and Washington channels of the Potomac river.*

Object of the appropriation.	Reference to laws by which the appropriation was made.				Amount required to be appropriated.
	Date.	Vol.	Page.	Sec.	
For the removal of the causeway of the Long bridge, and to replace the same by a bridge upon piles					$25,000 00
For dredging the Virginia and Washington channels					8,000 00
For dredging a channel eight feet deep, and from two hundred and fifty (250) to three hundred (300) feet wide, between Easby's Point and the eastern draw of the Long bridge, about 300,000 cubic yards					105,000 00
Total					138,000 00

V 3.

OFFICE OF PUBLIC BUILDINGS, GROUNDS, AND WORKS,
United States Capitol, Washington, April 30, 1868.

GENERAL: By section four of an act of Congress, approved March 2, 1867, (Public No. 59,) "making appropriations for the repair, preservation, and completion of certain public works, heretofore commenced under the authority of law, and for other purposes," the Secretary of War was directed to cause examinations or surveys, or both, to be made of certain points, among others of the Potomac river, in the District of Columbia. Subsequently, by engineer orders No. 67, dated July 27,

in charge of Mr. Clarence Fendall, assistant, executed the detail work, and subsequently prepared the maps of the same. To e these gentlemen I am greatly indebted for the interest displa prosecuting their labor, and especially to the latter for the compl and accuracy of its execution. The map is drawn on a scale o showing not only the hydrography of the river, but also the topogr conformation of the shore. The depth of the water at mean l is represented in feet. Observations of various kinds were m many points as to the nature of the soil at the bottom, the direct strength of the currents in the channels, and the action produ the rise and fall of the tides. It is found in water less than six fe the bottom is hard sand on the surface, through which an iron r inch in diameter, can be thrust six feet by the force of two m greater depths than six feet the rod could be pushed down from to ten feet with the same physical effort, and the bed on the su of soft mud. The points on the map which are colored in purple the positions where current observations were made; the arrows i the direction and velocity, one inch in length corresponding to o per hour. For the purpose of carefully examining what, if any, changes have taken place in the nature and depth of the channels, as of the general hydrographic condition of the river since previous s were made, a plan has been prepared showing the alterations tha taken place during a period of more than 60 years. The earlier d furnished principally from a map published in 1792, which approxi locates the channels and general features of the river at that tim previous to the construction either of the Long bridge or of the ca connecting the head of Analostan island with the Virginia shore. is not probably very reliable in its details, although confirming th lections of some of the older inhabitants with whom the subj long been familiar, but it is nevertheless very interesting and sugg The later information is obtained from more recent and accura veys made respectively in the years 1857, 1862, and 1867. That was made by Mr. R. W. Burgess, civil engineer, under the or Captain J. C. Woodruff, corps of topographical engineers United

nel. In the first a depth of seven feet could then be had, and in the second over nine; through the third or main one, the soundings show that at least 17 feet could have been carried through its entire length. The average width of these channels was about 200 yards, large, marshy flats separating them from each other. A large rock called Braddock's rock, at the base of the hill upon which the United States observatory now stands, is said to mark the spot where the British general in 1755 landed a portion of his war material when contemplating his move upon Canada. A channel of seven feet then existed where now extends a low, grassy expanse.

In the year 1806, the appropriation for which was made by Congress, and approved January 19, 1805, the causeway connecting Mason's island with the Virginia shore was thrown up for the purpose of deflecting the large body of water that then passed between the two into the main bed of the river, between the island and the Maryland bank. In consequence of this the channel south of the island, through which a draught of 18 feet could be had, has been entirely closed. Immediately below the causeway the depth of water is still over 30 feet, but gradually falls off to one or two. A grassy marsh has since been formed, and now extends for some distance below the extremity of the island. The Long bridge was constructed in 1809, that portion of it known as the causeway, 1,967 feet in length, having been built on the flats separating the channels, and the remainder on wooden piles and crib-work. Two draws for the passage of vessels are respectively 134 and 148 feet in the clear. Although the flats had previously existed to a wide extent, and have no doubt since been enlarged by the greater quantity of debris borne along by the river and deposited where the opposing forces of the current of the one and of the tidal influence from the ocean first encounter each other, these deposits yearly increasing in consequence of the more advanced culture of the rich regions through which the waters flow, still examinations recently made indicate that the flats have become more extensive, owing to the obstructions offered by the causeway, not quite so apparent above the bridge as below it. The recent surveys, those made in 1857, 1862, and 1867, at intervals of five years, indicate very decided changes in the regimen of the river as compared with that exhibited by the oldest accessible chart. Where formerly three channels existed, now only one is practically useful for the present tonnage of the sea-going vessels sailing between Georgetown and the Atlantic ports, and that has been slowly but gradually filling up for a short distance, so that upon the bar which has been formed scarce eight feet of water can be found at mean low tide. Vessels bound up or down have to wait for the flood-tide, creating delay and uncertainty. The old swash or shore channel has entirely disappeared, scarcely a foot of water over the flat upon the ebb-tide; so also with the one known as the Washington or city channel, the upper portion of which is closed to navigation, the present head being about midway between the north draw of the bridge and the Washington monument, and even at that point scarce seven feet of water can be depended upon. Only very light-draught boats, chiefly used for transportation of wood and lumber, pass through the draw of this channel to the entrance of the Washington canal, and then only on a high stage of water.

These great changes in the last 50 years have been the result of the constantly accumulating deposits in the bed of the river from the surface drainage and sewerage of the two cities, brought down by the Tiber and Rock creeks, from the washings from above and the wear of the banks by the varying currents, and from the effect of the ever-shifting

other from above and below, within 950 feet, with a channel of
feet connecting them. While up to the present period we find th
has been very little, if any, change in the depth of water betw
island and the Washington shore since the first chart was publis
position of the upper curve of 18 feet remaining almost identic
same, still, in descending the river by the Virginia channel, su
not continue to be the case; the depth had diminished since th
and by survey of 1857 the curve of 18 feet had receded over 7,
and its position then was only a short distance above the south
the bridge. In an interval of five years, as shown by survey of 1
same curve has commenced to advance up stream, although r
materially, having gained in that time about 360 feet. By the
vey, that of 1867, it is demonstrated that the same curve has co
to advance during a like interval, having moved up stream ov
feet in the last five years. At the latter rate it will not take
regain its position of 1792. These alterations have no dou
brought about by a combination of the causes above enumerate
by those powerful agents, which brook no control, the immense
arising from the melting of the snows of the mountains and th
falls of rain, together with the great accumulation and pressur
ice of winters when broken up and let loose by the advance of
Similar changes can be observed in the 6 and 12 feet curves of
ginia channel during the same intervals, at one time receding a
again advancing, although not to the same extent as in those o
feet. Along the course of the same channel, between the up
lower termini of the 12-feet curves, a distance of 2,000 feet, a
deposit has been forming for years back, creating at one poi
which has already seriously interfered with its navigation. Du
last survey not more than soundings of eight feet were found
mean low tide.

Whilst these alterations have been taking place in the Virgin

resume its old régime. Very little alteration has taken place in the shore lines above the Long bridge, and consequently, from this cause, the river has not been much deflected from its natural course. Immediately below the Little Falls the depth of water is over 80 feet, and continues very deep until the aqueduct bridge is reached. There the soundings indicate 24 feet in the channel. Thence to a short distance below the southern extremity of Mason's island it decreases considerably, varying from 25 feet to 18, although at some intermediate points there is as much as 35 feet of water, particularly opposite Easby's wharf. Below that point, as has already been described, the river spreads out over a wide surface, the current becoming more sluggish, and the channel gradually contracting for some considerable distance, with scarce eight feet at mean low tide. Then, as the Long bridge is approached, the Virginia channel again widens out and gradually deepens. At the draw it is over 24 feet, and continues to increase in depth as the descent is made.

The Washington channel, now heading but a short distance above the Long bridge, with only seven feet at its highest point, soon attains a depth of 12 as it passes through the east draw. Continuing to deepen, although but slightly, it in a short time joins, south of Greenleaf's Point on the arsenal grounds, the waters of the Eastern Branch. Vessels drawing 18 feet can ascend the latter as high as the wharves at the navy yard. Formerly they could reach Bladensburg, but, from natural causes, the bed has been filling up. About half a mile below their junction, the combined streams unite with the Virginia channel, from which they have been separated below the bridge by broad, grassy flats. A depth of 40 feet and over is then obtained in the main channel.

The survey of last year did not extend below the Long bridge, but that of 1862 includes that part of the river between the bridge and Giesboro' Point, about a mile below the arsenal.

From examination it is evident that the Washington channel, both below as well as above the bridge, is being seriously impaired. It has decreased in width as well as in depth. Some plan must be adopted for its improvement, and its execution should not be unnecessarily delayed. A very large part of the trade of the city is dependent upon keeping this channel open, and interested in preventing it from being further damaged by both artificial and natural causes. This part of the subject will be subsequently referred to.

From the previous and already too extended description of the present condition of the river, it is also plainly apparent that, in reality, there is but one channel of the Potomac—the Virginia channel—which is practically useful at present for commercial purposes, so far as the entire city of Georgetown and a large section of Washington are concerned, and how long this one will remain so is a question which concerns every one interested in the welfare and prosperity of the two cities.

The examination proves very conclusively that it is gradually becoming impaired by the continuous formation of a bar or shoal in the middle of the channel, which, extending now but a short distance, will finally assume greater proportions, unless some artificial appliances be resorted to for its removal. During the period the surveys were being executed sea-going vessels occasionally stuck fast on the bottom at low water.

Any one who seriously studies the subject must be forcibly impressed with the great necessity of adopting some system of improvement for deepening either one or both of the channels, or by cutting a new one through which to force the entire body of water of the Potomac, this

will never cease to be supplied in sufficient quantities for all navigable purposes. Instead of allowing the river to spread out over a wide surface, it should be confined in one channel, ample in width and depth; this once accomplished by the engineer, it will be found that nature will come to his assistance and aid in the operation of perfecting his plans. In anticipation of such improvements, legal measures should be taken for remedying all existing injuries to the channel, for the conservation of the shores and harbors, for preventing future encroachments in the construction of such works as may produce any damaging effect. Every encroachment should be received with the greatest jealousy. It need not be stated that the general government has a great interest in encouraging the river improvements to be proposed, and by assisting with liberal appropriations their execution. Had this step been taken before the late war it would be impossible to estimate the amount that would have been saved during that period; by the expediting of transportation alone, more than sufficient means would have accrued to compensate for the expense of the entire undertaking. Nor has the usefulness and necessity for such improvement on the part of the government ceased to exist; as long as the capital stands, so long will the need arise for a permanent and copious channel to meet the demands of commerce. As will be shown hereafter, the whole work will be remunerative in the greatest degree—the expense will be met by the advantages gained. It has been often stated that there are no more difficult and uncertain issues than those connected with the improvement of rivers, and, in submitting plans for those which will be proposed, it has been found desirable to endeavor to renew, as far as practicable, the old condition of the régimen of the river. As a great deal of time will necessarily be consumed in the preparation and obtaining of materials, and the construction of such necessary works as may be needed to execute any contemplated plan of permanent improvement, even should the necessary appropriation or other means become available, it is recommended, in the first instance, to dredge out that portion of the Virginia or Georgetown channel where the existence of the shoal water demands it, and also to the same extent the Washington or city channel below the Long bridge, so as to obtain a suitable depth of water in each for such sea-going vessels as are of a proper tonnage for the trade of the river. The present channel will then be preserved for immediate use in the event of no funds becoming tangible within a reasonable time for more extended and important improvements. The channel ways should be in the minimum at least of 100 feet in width, with a depth of 12 feet at mean low water. In view, however, of the improvement to be finally proposed, it will only be necessary at present, as far as the Washington or city channel is in question, to dredge such shoals or bars as immediately require alteration, without going into any extension of its width. This will be attended with very little expense and not much loss of time; the machinery and labor to be employed becoming available during any temporary suspension on the other adjoining works. In respect to the Virginia channel, the plan for its present improvement is represented in the accompanying sketch, which exhibits the plan and profile, marked B, for connecting the 12-feet water curves. The distance to be dredged is 1,900 feet, and by calculation the amount of soil to be removed will be about 10,191 cubic yards. The distance is divided into sections of 100 feet, and the contents of each can be found by reference to the annexed table, marked channel B. Should the engineer in charge desire to accomplish the work without contracting for the same, it may be well to mention, as the questions are frequently asked, that one of the best dredging machines is said to be Osgood's patent, which, according to the latest and most reliable information, can

aise from 300 to 500 cubic yards of soft mud or sand per day. Each of the machines owned by the government, and used at present in the Patapsco river, cost about $10,500. An estimate for this temporary improvement will be appended. Whatever opinions may be held or have been expressed by others in regard to the obstruction or encroachment in the river, in consequence of the building of the causeway of the Long bridge, it has been clearly demonstrated to me that there is no doubt of that structure being very injurious to the Washington channel, and that the section referred to should, therefore, be removed and replaced by either an arched bridge or one on piles of iron or wood. Those best acquainted with the river have pointed out a most marked increase during the last few years in the dimensions of the flats, and a consequent diminution in the width and depth of the channel. Whilst the causeway obstructs, to a considerable extent, the water coming down from the interior of the country, it also partially prevents the tide-water from flowing up; it therefore interrupts that continual scour which should result from the force of the one, and the flowing and ebbing of the other; the tides should have a perpetual and unrestricted current. 'The great object to be kept in view, in carrying into effect the improvement of the navigation of a tidal river, is the free admission of the greatest possible quantity of water from the sea, as reliance must be chiefly placed upon the scour produced by the tide, and not upon the current of the fresh water as the chief agent in keeping open the navigable channel of the river." Many celebrated engineers have concurred in the above opinion; and this being admitted, "it is manifest that all obstructions to the tidal flow upwards should be removed," such as shoals and bars, or dams and dikes, or any other cause of obstructions. The length of the causeway, as already stated, is 1,967 feet, a somewhat formidable obstacle to either river current or ocean tide, and the estimated cost of substituting for it the most simple plan of bridge, the pile or trestle or crib work, will not require a very large expenditure in proportion to the advantage to be gained. It is difficult to understand why the causeway was originally constructed. An estimate for its removal is herewith appended.

In my last annual report, dated October 1, 1867, it was stated that orders had been given me to prepare a special report to the bureau in regard to the improvement of the channel of the river, and that the bridge question was so intimately associated with the matter as to necessarily form a part of the document. Since then two very interesting and comprehensive reports in reference to bridging the Potomac at several points have been carefully examined, and the subject found to be very thoroughly exhausted. Should either of the plans proposed in reference to the present site of the Long bridge be adopted, it would necessitate the removal of the causeway. These reports were made at different periods to the Department of the Interior; the one was prepared by Alfred C. Reeves, esq., civil engineer, and submitted to Congress by the Hon. R. McClelland, then Secretary, on the 7th of February, 1857, and the other by Colonel Silas Seymour, civil engineer, addressed to the Hon. O. H. Browning, the present Secretary, on the 18th of February, 1868.

The first report was printed several years ago for distribution, and the perusal of the second in the original manuscript was kindly afforded me by the author.

We have now discussed the temporary and at the same time the most economical and expeditious plans for improving the navigation of the existing channels: firstly, by deepening the two channels, the Washington or city, and the Virginia or Georgetown, by dredging the shoals to the depth of 12 *feet at mean low* water; and secondly, by the removal

of the causeway of the Long bridge, which contracts the current and obstructs the flow of the tide, in order to obtain a larger volume of water to assist in scouring them out. The velocity of the current, upon which mainly the scouring process depends, is not great; the greater the reason, therefore, for removing any obstacle to its free action. It may be here stated that the rise and fall of the tides is about three feet, and that the velocity of the current in the channel is one-half mile per hour. The next questions to be considered have reference to some plan for the permanent improvement of the navigation of the river; several have been recommended, but to the present time not one has been executed or even adopted. There is a division of opinion as to whether one or both of the old channels shall be improved, and again whether both of them ought not to be closed and an entirely new one opened. One good, straight, broad channel will certainly be more preferable than two inferior ones, and the one which promotes the greatest amount of benefit and is most advantageous for the commercial interests of both cities, Washington and Georgetown, should be adopted, although it might not prove the most economical in the first instance.

If one can, therefore, be dredged out which will conform, as closely as possible, to the regimen of the river as it existed many years ago, before its waters were obstructed by the encroachments since made upon it, and should legal measures be taken to remove the latter, it would seem that such are the steps needful to be taken.

From the different surveys made it is evident that the current of the river has still a tendency to set in the direction of the old Washington or city channel as laid down on the earlier maps, running parallel to the bold curved shore which forms the city front; a pocket has been formed showing this tendency, and within the last few years it has been gradually extending and deepening. The current is somewhat deflected from taking what otherwise would apparently seem to be its natural course by the encroachment of Easby's wharf, and by obstructions offered at and near the same place by rocks which appear above and below the surface of the water, and which should be removed before any extended improvement is commenced. What would then seem to be the most natural plan is to connect deep water a little above the east draw of the Long bridge, where the river washes against high bluff banks, with deep water below Easby's wharf, the course of the new channel following the general direction of the current, and taking advantage at the same time of the most favorable profile.

The plan and profile of the proposed new channel is exhibited in one of the accompanying sketches. It should be at least 12 feet in depth at mean low water, and 100 feet in width; the length of the cut will be about 5,700 feet, and the quantity of soil to be removed is calculated to be 162,621 cubic yards. An examination of the bottom of the river proves that it is perfectly feasible to dredge the channel to the necessary depth, frequent borings of the sub-soil having furnished satisfactory results.

In computing the cubic contents to be removed proper allowance has been made for the caving in of the sides of the channel, assuming that they will take a slope of 45°, the soil being composed of hard sand. The material removed can be conveniently deposited on the grassy marsh between the edge of the channel and the main slope, thereby embanking and reclaiming about 220 acres, the greater part of which would prove an extension to that part of the public grounds called the Mall. Although it is not advisable to contract the banks so as to prevent the spread of the water and intercept the tidal flow, still as the river is so broad at this point and the space reclaimed so limited, no very serious damage can be anticipated.

Among the several river improvements of the present century which have proved most successful, the greatest depth of water has been obtained by artificial means, principally by dredging, aided when favorable by the scouring process of the tides. Should the soil prove too soft and not adopt a proper slope, quarter or half tide dikes can be used to guard the channel. A more substantial and permanently useful improvement for protecting it along the city front would be to build a sea-wall, which would also act as a retaining wall for the reclaimed land.

By opening this new channel the force of the current will aid in scouring out that part of the old city channel below the Long bridge, which, as has already been stated, is being seriously impaired. The removal of the causeway of that bridge is a *sine qua non* in respect to the successful execution of any of the plans. Nor will this improvement produce any injurious effect upon the channel of the East Branch, as the two glide into each other at an acute angle and together assume a gentle continuation of the curve of the shore as far down as Alexandria, where it is again deflected towards the opposite bank.

Appended is a table marked channel A, exhibiting the contents of each section of a hundred feet through the proposed cut, and an estimate for dredging the channel is annexed.

Whether or not sufficient water will pass through the new channel when opened, without the aid of the artificial appliances, to deflect it from the Virginia channel, is a question requiring great consideration; and the fact of the Potomac being influenced by the tides to a higher point than the proposed work, renders it necessary to examine whether or not dikes might be so constructed, without proving injurious, as to give to the current a suitable direction. If properly directed, the whole mass of water can be usefully employed, instead of wasting its power by being spread over the present broad surface of its bed.

In the very able and suggestive report by Mr. Alfred Reeves, to which reference has already been made, upon the subject of opening a new channel, he proposes the building of a breakwater from the southern extremity of Mason's island to deflect the current. In the same connection he remarks that the advantages resulting from a combination of the arrangements suggested would be permanent, "because the river will be confined in a sufficiently narrow channel for more than a mile below Easby's wharf by the proposed breakwater, which it leaves in a direction normal to the Long bridge, finally passing through the opening reserved for it, and becoming tangent to a bold curved shore of wonderfully regular outline. It is well known that currents in curves form stable and deep channels." The building of such a breakwater would have the tendency, sooner or later, to close entirely the Virginia channel; instead of being preserved for navigable and commercial purposes, its place would be occupied by marsh or meadow-land which would eventually form; this would be but a continuation of the process already going on, in consequence of the building of the causeway at the head of Mason's island.

Again, in constructing such a breakwater or dike, and thus contracting the width of the stream, what would be the general effect in the course of time upon the new channel, should one be opened, and would not such a work, perhaps, prove an impediment instead of an improvement to navigation, by preventing and thereby decreasing the flow of tide? Considering, however, the very great width of the Potomac opposite the two cities, where the upward tidal flow and the downward current of the river encounter and apparently hold each other in check, and also the short distance above the proposed improvement to which the tide ascends, to say nothing of the small rise, it does not seem very

sections, and as it progresses the practical effect upon the acti current could be observed, and any needed change in the pl suggest itself. The section across the Virginia channel shoul last one completed, in order not to interfere until the last mom the navigation through it. It is a question, especially in an ec point of view, whether a breakwater from the southern extr Mason's island, and parallel to the current of the river, will advantageous than a dam or pier built perpendicular to its direction, and extending from the Virginia shore, across the old to near the edge of the new one. On the sketch the position a dam is located, it being laid down along the line of least wate profile will show. The selection of a dam, in preference to th water proposed by Mr. Reeves, is that the first will be much more conveniently built, and consequently a more economical s The difference in the practical working of each will not be ve The report which gained some currency during the early part and assumed an official recognition by the action of the Board of the city of Washington, in offering a preamble and resolutic 11th of February of that year, that the previous heavy "freshe Potomac had caused the channel on the Virginia side of the ri blocked up so as to cause the flood to seek an outlet across known as the 'flats,' thereby opening the original channel of th ington side of the river," was not entirely based upon the facts exist, the recent survey proving that no such change had taken the great extent above quoted. It was also stated that the l formed a natural breakwater, similar in its effect to the one pro Mr. Reeves. This combined action of the freshets and ice will account for the tendency, already mentioned, in the river to re old channel, and offers a strong argument in support of the posed.

If the plan for a dam should be adopted, the following woul dimensions: The required length is 2,560 feet, with a width of 1 top and 15 feet in height, the average depth along it being 9

to the unhealthy condition of the atmosphere, and presenting so unsightly an appearance, would be reclaimed, and in a short time, it is to be hoped, add greatly to the beauty of the public grounds in that section.

Again, by opening a cut for the Tiber to pass into deep water of the new channel, the sewerage of the city, a subject which should receive most careful and studied attention on the part of its inhabitants, would be scoured off by the strong currents of the river, instead of spreading over the flats and generating pestilential vapors, with which to infect the whole community. These great advantages will certainly deserve the consideration of the reflecting citizen, and compensate for the comparatively small pecuniary expense of the undertaking.

A statement, setting forth the amount of tonnage arriving at and departing from both Washington and Georgetown during the last year, 1867, is appended.

The following is a list of maps and plans which accompany this report:

1. Map of Potomac river, published in 1792.
2. Map of Potomac river, surveyed in 1857 by Captain Woodruff.
3. Map of Potomac river, surveyed in 1862 by Captain Patterson.
4. Map of Potomac river, surveyed in 1867 by Mr. Fendall.
5. Plan showing the alterations in the channel of the Potomac river, ascertained by surveys in 1792, 1857, 1862, and 1867.
6. Hydrographical map of the Potomac river, above the Long bridge, showing the proposed channel and dam for connecting deep water at Georgetown with deep water at the Washington wharves. Channel 100 feet wide and 12 feet deep. Also, a plan for connecting the 12-feet water-curves in the Virginial channel. Hydrography from soundings made in 1867, and reduced to mean low water.

I am, general, very respectfully, your obedient servant,

N. MICHLER,
Major of Engineers, Bvt. Brig. Gen. U. S. A.

Major General A. A. HUMPHREYS,
Chief of Engineers, Headquarters Corps of Engineers,
Washington, D. C.

CHANNEL A.

Section.	Length.	Average depth.	Cubic yards to be removed.	Section.	Length.	Average depth.	Cubic yards to be removed.	Section.	Length.	Average depth.	Cubic yards to be removed.
	Feet.	*Feet.*			*Feet.*	*Feet.*			*Feet.*	*Feet.*	
1	100	11	374	21	100	5	2,774	41	100	1¼	4,296
2	100	10¼	659	22	100	4¾	2,881	42	100	1¼	4,296
3	100	10¾	470	23	100	3¾	3,307	43	100	1¾	4,185
4	100	9¼	948	24	100	3¾	3,533	44	100	1¾	4,185
5	100	9¼	948	25	100	3¾	3,533	45	100	1¾	4,185
6	100	8¼	1,407	26	100	3¾	3,307	46	100	1¾	4,185
7	100	8¾	1,274	27	100	4	3,200	47	100	1¾	4,185
8	100	8¾	1,274	28	100	3	3,633	48	100	1	4,522
9	100	8	1,541	29	100	3	3,633	49	100	2¼	3,744
10	100	8	1,541	30	100	2¼	3,852	50	100	3¼	3,407
11	100	7¾	1,674	31	100	2¼	3,963	51	100	4¼	3,093
12	100	7¼	1,811	32	100	2	4,074	52	109	5	2,774
13	100	6¼	2,148	33	100	1¾	4,185	53	100	5¼	2,563
14	100	7	1,944	34	100	1¾	4,185	54	100	7	1,944
15	100	6¼	2,148	35	100	1¼	4,296	55	100	8¼	1,333
16	100	6¼	2,219	36	100	1¼	4,296	56	100	9¼	948
17	100	6	2,356	37	100	1¾	4,185	57	100	9¾	852
18	100	5¼	2,563	38	100	2	4,074				
19	100	5¼	2,563	39	100	1¾	4,185				
20	100	5¾	2,670	40	100	1¼	4,296				162,621

CHANNEL B.

Section.	Length.	Average depth.	Cubic yards to be removed.	Section.	Length.	Average depth.	Cubic yards to be removed.	Section.	Length.	Average depth.
	Feet.	*Feet.*			*Feet.*	*Feet.*			*Feet.*	*Feet.*
1	100	11	374	8	100	9½	947	15	100	11½
2	100	10½	563	9	100	11	374	16	100	10
3	100	11½	185	10	100	10½	563	17	100	10½
4	100	10	756	11	100	9½	947	18	100	11½
5	100	9	1,144	12	100	11	374	19	100	11½
6	100	8½	1,341	13	100	11½	185			
7	100	10½	563	14	100	11½	93			

Estimate of river improvements.

	Cubic yards.	Cost per cubic yard.	Amount.	Remarks.
Removal of causeway at Long bridge..	34,867	$0 40	$9,966 80	Brickwork, stone, and filli
Section of bridge to replace causeway..	.....	.....	15,000 00	400 piles of 40 ft. each, floori 300,000 ft., board measu
Dam or breakwater foundation, and superstructure masonry and coping.	26,000	15 00	390,000 00	
Dredging new channel.....	162,621	35	56,717 35	
Total.....	.....	.....	471,864 15	
VIRGINIA OR GEORGETOWN CHANNEL.				
Dredging.....	10,191	35	3,566 85	

CUSTOM-HOUSE, *Georgetown, D. C., May* 16, 18

SIR: The custom district of Georgetown comprises all of the Di of Columbia and the Maryland side of the Potomac river for 30 below this, and to the headwaters of the Potomac on the Maryland

The tonnage of vessels belonging to this district is 22,455.88 The number of vessels entered for the past year, 373. Number o sels cleared for the same time, 205.

You cannot judge of the amount of business done in this district the number of vessels entered and cleared, for vessels in the coa trade are not required to enter or clear at the custom-house unless have foreign goods or distilled spirits on board. I suppose there least 20 vessels arriving here, which do not enter or clear, for eac that has to do so.

Very respectfully, your obedient servant,

JAMES A. MAGRUDER,
Collec

General N. MICHLER,
In charge of Public Buildings, Grounds, and Works,
United States Capitol, Washington, D. C

APPENDIX W.

Annual report of the survey of the north and northwest lakes, for the year ending June 30, 1868; Brevet Brigadier General W. F. Raynolds, lieutenant colonel of engineers, in charge.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, September 15, 1868.

GENERAL: I have the honor to submit this my annual report of the operations of the survey of the north and northwest lakes for the year ending June 30, 1868.

The date to which a report is required being in the middle of the season of active field operations, I shall follow the course pursued for the past two years, and make my report under three distinct heads, as follows:

1. The field of operations of the different parties, and the amount of work done by each during the season of 1867, as well as the office-work of the same parties during the past winter.
2. The organizations of the different parties for the present season, with their different fields of operations.
3. Give a brief sketch of the present condition of the survey, with the outline of a programme for its continuance.

On the 1st of July, 1867, the several parties of the survey were at work in their different fields of operations, having sailed from this city on the dates specified in my last annual report.

Their respective duties and the work executed by each were as follows:

Brevet Lieutenant Colonel F. U. Farquhar, captain corps of engineers, was in charge of the party on board the steamer Search, and under instructions—

1. To make the off-shore soundings in Lake Superior, from Grand island eastward as far as practicable, or until he met the work of Assistant O. N. Chaffee.
2. To carry supplies to three shore parties between Marquette and the St. Mary's river; to move their camps, &c.
3. To make reconnoissance, to determine the most suitable points to be occupied by the astronomical parties; to locate them at the points selected; keep them supplied with provisions, &c.
4. To make reconnoissance for points of primary triangulation in the eastern portion of the lake.
5. The survey of all shoals and small islands beyond the reach of small boats.
6. To have a general supervision of all the parties in Lake Superior, and in my absence to give such instructions as would secure satisfactory results from their work.

In the discharge of these duties the following work was performed:

Number of primary triangulation stations built	3
Number of sounding stations built	16
Number of sextant angles read	110
Number of theodolite pointings	3,880
Number of theodolite readings	7,760
Number of lines sounded with steamer	97
Number of miles sounded with steamer	1,081
Number of casts of lead from steamer	921
Number of square miles of off-shore hydrography	1,164

Number of barometer readings for heights	14
Number of vertical angles for heights	2
Number of heights measured	
Number of theodolite pointings for primary triangulation	96
Number of theodolite readings for primary triangulation	38
Number of miles run by steamer on general duty	7,97

The above work was plotted during the winter on 1⅛ sheets of an quarian paper, on a scale of one one hundred and twenty thousandth embracing 420 square inches of off-shore hydrography.

First Lieutenant James F. Gregory, corps of engineers, was in char of the party on board the steamer Surveyor, under instructions—

1. To take off-shore soundings around Isle Royale.
2. To triangulate the channel between the island and the Canad shore north of it.
3. The survey of all shoals or small islands beyond the reach of sh parties; and
4. To afford aid to, and exercise supervision over, the shore partie Isle Royale, similar to that exercised by Colonel Farquhar over thos the south shore.

On the 15th day of August Lieutenant James Mercur, corps of e neers, having been relieved from duty on the lake survey, Lieute Gregory was placed in charge of the astronomical party, and Lieute B. D. Greene transferred to the steamer Surveyor.

This party completed the survey of Passage and Gull islands, loc and sounded out three shoals, and discovered and surveyed ano heretofore unknown, beside finishing about one-half of the off-s soundings around Isle Royale.

The following are the details of the work accomplished by them:

1.—MINUTE HYDROGRAPHY AND TOPOGRAPHY.

Number of miles of shore-line run	
Number of triangles measured	
Number of sounding stations built	
Number of buoys put out and located	
Number of lines sounded with small boats	1
Number of casts of the lead	1,4
Number of miles measured with stadia	
Number of vertical angles measured	
Number of compass readings	

2.—OFF-SHORE HYDROGRAPHY.

Number of sounding stations built	
Number of lines run	
Number of casts of the lead	
Number of sextant angles read	
Number of theodolite pointings	1
Number of theodolite readings	2

The in-shore work was plotted during the past winter, on a scale of twenty-four thousandths, covering one sheet of antiquarian paper, embracing 23 square inches of topography and hydrography.

The off-shore hydrography was plotted on a scale of one ninety thousandths, and covered one antiquarian sheet, embracing 223 sq inches.

Assistant O. N. Chaffee was in charge of the party on board the steam

nder instructions to take up the primary triangulation of Lake
or, east of Keweenaw Point, and push it forward as rapidly as pos-
s far as the triangulation could be carried to the eastward. Hav-
npleted this duty, he was directed to commence the off-shore
raphy at the head of the St. Mary's river, and continue it to the
est, around White Fish Point, until he met and connected with
rk of Lieutenant Colonel Farquhar. He was also directed to
he necessary reconnoissance and triangulation to determine the
l contour of the Canadian shore south of White Fish Point.
following are the details of work accomplished during the season:

r of primary triangulation stations built	3
r of theodolite angles	131
r of theodolite pointings	5,999
r of miles run on general duty	3,390

days were spent in reconnoitering for a new position for station
Huron mountains.
ver for two additional stations was prepared.
duction of the above work was commenced, chiefly by Assistant
Chaffee, during the past winter, on a scale of one three hundred
ndths; and 98 square inches of hydrography and topography was
ted.
ldition to this Assistant Chaffee's work on the flats of Lake St.
a summary of which was given in the last annual report of the
rvey, was plotted, and comprised one sheet of antiquarian paper,
ale of one three thousandths, covering an area of 84 square inches,
3 profiles of longitudinal sections; and one sheet of antiquarian
on a scale of one sixteen thousandths, embracing 350 square
of topography and 150 square inches of hydrography.
Lieutenant B. D. Greene, corps of engineers, was in charge of a
party, charged with making a topographical and hydrographical
of the south side of Isle Royale, including the numerous islands
rbors adjacent thereto, commencing at the most eastern point of
nd, and extending westward as far as practicable.
field included the beautiful bay of Rock Harbor, over fifteen
ng, and affording perfect protection against every wind.
he 23d of August the party was transferred to the base line to
preparing it for measurement, previous to which date the fol-
work had been accomplished:

r of secondary triangulation stations built	108
r of sounding stations built	173
r of buoys placed out and located	54
r of sextant angles	8
r of theodolite pointings	4,055
r of theodolite readings	5,819
r of lines sounded with small boats	797
r of miles sounded with small boats	324
r of casts of lead from small boats	8,701
r of square miles of in-shore hydrography	12½
r of miles of shore-line run	71
r of square miles of topography	17
r of vertical angles for topography	158
r of miles run with stadia for topography	70
r of secondary base lines measured	2
r of compass bearings for magnetic declination	50
r of observations for true meridian	2

This work was plotted during the winter on four sheets of antiquarian paper on a scale of one sixteen thousandths, and embraced with the St. Clair river work, the details of which were given in my last annual report, (which was also plotted,) 425 square inches of topography and 225 square inches of hydrography.

Assistant A. C. Lamson was in charge of a topographical and hydrographical party on Isle Royale under instructions to survey the north side of the island, commencing at the most eastern point and working to the westward as far as practicable.

The field assigned to this party embraced a bold, rocky shore, and numerous small islands having deep passages between them as well as many shoals and rocks, which required careful surveys to show their extent and locality.

On the 23d of August this party was transferred to the base line to assist in preparing it for measurement.

The details of work accomplished previous to being transferred to the base line are as follows:

Number of secondary triangulation stations built	150
Number of sounding stations built	399
Number of buoys placed out and located	52
Number of theodolite pointings	3,960
Number of theodolite readings	5,208
Number of compass bearings	39
Number of observations for true meridian	1
Number of lines sounded with small boats	1,236
Number of miles sounded with small boats	443
Number of casts of the lead from small boats	11,779
Number of square miles of hydrography	17
Number of miles of shore-line	75
Number of square miles of topography	20
Number of vertical angles for topography	101
Number of miles run with stadia for topography	5
Number of secondary base lines measured	2
Number of angles measured	31

Which was plotted on two sheets of antiquarian paper on a scale of one sixteen thousandths, and embraced 251 squares inches of topography and 258 square inches of hydrography.

Assistant Henry Gillman was in charge of a shore party on the south side of the lake, and under instructions to make a topographical and hydrographical survey, commencing at Grand island and continuing westward until his work joined the survey of Marquette harbor previously made. After completing this work he was instructed to continue to the westward and make a survey for the improvement of the Chocolate river and its approaches, in accordance with instructions received from the department. This was accomplished on the 24th of August, when the party was transferred to the base line to assist in its measurement.

The following are the details of work accomplished by assistant Gillman's party previous to being transferred to the base line:

Number of secondary triangulations stations built	4
Number of sounding station built	86
Number of buoys placed out and located	88
Number of sextant angles	25
Number of theodolite pointings	2,342
Number of theodolite readings	3,778

Number of compass bearings for magnetic declination	153
Number of observations for true meridian	4
Number of lines sounded with small boats	705
Number of miles sounded with small boats	684
Number of casts of the lead with small boats	27,743
Number of square miles of in-shore hydrography	33½
Number of square miles of topography	34¾
Number of vertical angles for topography	348
Number of miles run with stadia for topography	24¾
Number of miles of line of sight opened	2
Number of miles of shore-line run	41¼
Number of secondary base lines measured	1

The above work was plotted on three sheets on a scale of one sixteen thousandths, with the exception of the Chocolate river survey, which was on a scale of one four thousandths; the whole embracing 440 square inches of topography and 635 square inches of hydrography.

Assistant J. R. Mayer was in charge of a shore party, and under instructions to commence work at Grand island, and continue to the westward until his work joined that of Assistant Albert Molitor.

The field assigned to this party included the well known Picture Rocks, which were supposed to afford no landing, even for small boats, for many miles, but which were found to be much less formidable than was expected.

Assistant Mayer returned to this city on the 1st of October, having performed the duty assigned him.

The following are the details of work accomplished:

Number of sounding stations built	251
Number of buoys placed and located	159
Number of theodolite pointings	3,084
Number of theodolite readings	3,070
Number of lines of soundings	1,109
Number of miles of soundings	875
Number of casts of the lead	29,389
Number of square miles of hydrography	50½
Number of square miles of topography	21¾
Number of miles run with stadia for topography	21½
Number of meridian lines observed	4
Number of miles of shore-line run	67½

The above work was plotted during the winter on a scale of one sixteen thousandths, and covered five sheets of antiquarian paper, embracing 866 square inches of hydrography, and 464 inches of topography.

Assistant Albert Molitor was in charge of a shore party, and under instructions to commence his surveys at the most northern point of the surveys heretofore made in the St. Mary's river and Yaquamenon bay, and continue his work from that point north and west until he met and closed upon the work of Assistant Mayer, which was accomplished before returning from the field.

The following are the details of work performed by this party:

Number of secondary triangulation stations built	66
Number of sounding stations built	151
Number of water stations built	1
Number of buoys placed out and located	263
Number of sextant angles	166
Number of theodolite pointings	4,246

Number of theodolite readings	5,878
Number of compass bearings for magnetic declination	20
Number of observations for true meridian	3
Number of lines sounded with small boat	1,407
Number of miles sounded with small boat	957
Number of casts of the lead from small boat	45,290
Number of square miles of in-shore hydrography	68
Number of miles of shore-line	67 1/10
Number of square miles topography	90
Number of vertical angles for topography	80
Number of miles run with stadia for topography	41
Number of secondary base lines measured	2

The above work was plotted during the past winter on a scale of one sixteen thousandths, on four sheets of antiquarian paper, covering 1,104 square inches of hydrography and 1,451 square inches of topography.

ASTRONOMICAL AND PRIMARY TRIANGULATION PARTY.

First Lieutenant James Mercur was placed in charge of this party with instructions to separate it into three divisions, two of which were to be under charge of Assistant O. B. Wheeler and G. Y. Wisner; and to station their divisions at the apices of the larger triangles of the primary triangulation, and to determine astronomically the positions of those points, and at the same time to read the angles for the triangulation.

The instruments with which they were furnished for the last-named duty were those named in my last annual report as having been borrowed from the Coast Survey.

The proposed scheme of triangulation over a large portion of Lake Superior depended upon the possibility of reading the angles of one large triangle covering that portion of the lake lying northeast of the extremity of Keweenaw Point, the sides of it being 92, 93, and 101 miles long, respectively. I have already reported that the required angles were read and thus the ability to triangulate the lake demonstrated.

On the 15th of August, Lieutenant Mercur having been relieved from duty on the lake survey, Lieutenant Gregory was assigned to the command of the astronomical party, and continued with it to the close of the season.

During the latter part of the season this party was transferred to the south shore to connect the work done in Keweenaw bay with that in the St. Mary's river.

A full report of their operations will be found herewith, marked Appendix —.

The following is a brief summary of work performed:

Number of astronomical stations occupied	
Number of stars observed for local time	1,7
Number of stars observed for latitude	2,6
Number of theodolite pointings for primary triangulation	9
Number of theodolite readings for primary triangulation	2,7

THE DETERMINATION OF THE LENGTH OF THE STANDARD-BAR BELONGING TO THE LAKE-SURVEY BASE-MEASURING APPARATUS.

The measuring apparatus belonging to the lake survey was procured in 1852, and has been used in the measurement of all base lines since that date.

Constant use has made an almost imperceptible dent in the ends of the standard bar, on which all measurements depend. It was, therefore, deemed advisable to have agates inserted so as to prevent further wear. This rendered a redetermination of the length of the bar necessary. Its approximate length is 15 feet.

Five standard brass yards were procured from the Office of Weights and Measures, and the duty of comparing the length of the "15-foot bar" with these standard yards was intrusted to Brevet Lieutenant Colonel F. U. Farquhar, whose report on the subject will be found herewith appended, marked Appendix A.

DESCRIPTION OF BASE APPARATUS AND OF THE METHOD OF USING IT.

The lake-survey base apparatus was made by Mr. William Wurdemann, of Washington, after the most approved pattern, agreeing in all essential particulars in construction with that in use on the coast survey.

A partial description of the apparatus (without drawings) was published by Captain T. J. Lee, corps of topographical engineers, in a report dated June 1, 1854.

Believing that a more minute description, with drawings, as well as an account of the practical method of using it, will be of essential service to officers of the corps, as well as others who may hereafter have occasion to make careful measurements of bases, I have had detailed drawings of the apparatus made by Assistant E. S. Wheeler, of the lake survey, as well as a description of the apparatus and the mode of using it, prepared, which is herewith submitted, marked Appendix B.

BASE LINE.

A base line was selected in the fall of 1865 on the west side of Keweenaw bay, south of Portage entry, and during the following winter was cut out to the width of 50 feet throughout its entire length of over five miles.

All the stumps and roots were removed for a width of 15 feet, which width was also plowed to prevent the unfavorable effect of small roots that could not otherwise be got rid of, and the whole line prepared for measurement.

Upon the 1st of September, 1866, Assistant D. F. Henry commenced the measurement of the line, but the season being unusually rainy, and arrangements for drainage proving incomplete, it was found impossible to measure more than 284 tubes before the close of the season; and the ground was so unstable as to render even these unreliable.

During the latter part of last year the work was again undertaken by Assistant Henry, aided by a strong force drawn from other parts of the work, as has been stated, and successfully accomplished.

A full report of the measurement of this line will be found herewith, marked Appendix C.

OUTFLOW OF THE LAKES.

In the early part of the summer two small parties were organized for the purpose of determining the amount of water flowing through the rivers connecting the chain of lakes.

One of these parties was stationed at Sault Ste. Marie on the St. Marie's river, and the other on the St. Clair river at St. Clair—Assistant D. F. Henry having general charge of both—Assistant Lewis Foote being stationed at Sault Ste. Marie, And assistant A. R. Flint at St. Clair.

On the 12th of August Assistant Foote was transferred to Fort Niagara on the Niagara river, and Assistant Flint to Ogdensburg, on the St. Lawrence.

Assistant Henry's report on the season's work will be found herewith, marked Appendix D.

These observations have been continued during the present season and it is probable that one or two additional seasons will be required before arriving at entirely satisfactory results.

METEOROLOGICAL DEPARTMENT.

Observations have been carried on during the year at 13 stations on the lakes, as usual, this being the eighth year since they were commenced.

For the past two years this work has been under charge of Assistant D. F. Henry, whose annual report on this subject, with data, &c., will be found herewith, marked Appendix E.

OFFICE WORK—REDUCTION OF MAPS FOR THE ENGRAVER.

During the year two reduced maps have been forwarded to the bureau for publication. One by Assistant J. U. Mueller, on a scale of $\frac{1}{40000}$, comprising the north end of Lake Michigan, including the Straits of Mackinac and Green Bay. The other by assistant Edward Molitor, on a scale of $\frac{1}{120000}$, of the south end of Green Bay from Fox river as far north as the Rock island entrance.

Assistant Mueller is now engaged upon a final chart of Lake Superior from Grand island to Ontonagon, on a scale of $\frac{1}{100000}$.

During the winter months Lieutenant L. M. Houpt, corps of engineers, was employed in reducing a map of Big and Little Sturgeon bays; and Assistant O. N. Chaffee was occupied on the reduction of Huron bay and Huron island, Lake Superior.

It is proposed to resume the reduction of these maps as soon as possible, and it is hoped that before the services of these gentlemen will again be required in the field they will be ready to finish these maps, ready for the engraver.

REDUCTION OF MAPS ON STONE.

On the 14th of January I applied to headquarters for authority to have two preliminary maps of portions of Lake Superior engraved on stone in this office, directly from the field maps, in order to disseminate the information obtained by the survey as soon as possible, by anticipating the final engraved map.

This authority was granted on the 17th of the same month, and after some delay in procuring stones, &c., the first map of the south shore of the lake from Grand island to Ontonagon was commenced by Assistant Edward Molitor, and completed July 24th, when it was sent to the printer, and an impression forwarded to headquarters July 27th.

The distribution of this map has already commenced, and it is believed it will be found of essential service until the final completed map can be produced.

CHART DISTRIBUTION.

This duty has been carried on as usual, there having been 6,354 charts distributed during the year.

A tabular statement, showing the number issued of each kind during

the year, and also the total number issued, will be found herewith, marked Appendix F.

An examination of the table shows that the demand for charts is constantly increasing, proving the growing appreciation of the labors of the survey by those interested in the commerce of the lakes.

The following officers of the corps of engineers reported for duty on the lake survey on the dates named, and were at once assigned to the different parties on Lake Superior: First Lieutenant John C. Mallery, August 6, 1867; Second Lieutenant Lewis M. Haupt, August 6, 1867; Second Lieutenant William E. Rogers, September 7, 1867; Second Lieutenant Joseph E. Griffith, September 16, 1867; First Lieutenant Ernest H. Ruffner, September 19, 1867.

FIELD OPERATIONS FOR THE SEASON OF 1868.

The following programme for continuing the survey during the season of 1868 was submitted by me on the 6th of March, and approved at headquarters March 9:

1. One steamer for continuing the reconnoissance for primary triangulation of Lake Superior to the westward as far as practicable.

2. The continuation of astronomical observations at the points of primary triangulation, and the reading the angles of primary triangulation, by three divisions of the astronomical and primary triangulation party.

3. The completion of the topographical and hydrographical survey of Isle Royale, requiring two shore parties.

4. The survey of the north shore of Lake Superior, from Pigeon river (the boundary between the United States and the British possessions) westward, to join the survey heretofore made from the head of the lake, requiring two shore parties.

5. One steamer to continue the off-shore hydrography of Lake Superior.

6. The continuation of the survey of the south shore of Lake Superior, from the vicinity of Ontonagan westward to the vicinity of Bayfield, requiring one shore party.

7. Repeat the observations for determining the outflow of the lakes, at three points, one in each of the rivers St. Clair, Niagara and St. Lawrence. Observations to be continued through the season. For this duty three small parties will be required.

8. One party on board a steamer to complete the triangulation of the large bay south of White Fish Point, and the necessary hydrographical and topographical surveys to give a chart of that locality.

To carry out this programme, the different parties left for their fields of operation in the following order:

On the 16th of May the party under command of Second Lieutenant Joseph E. Griffith, corps of engineers, left for Lake Superior on the steamer Keweenaw, charged with the duty of making a topographical and hydrographical survey of the coast west of Ontonagon.

On the 18th of the same month, Brevet Lieutenant Colonel F. U. Farquhar, captain corps of engineers, sailed on the steamer Ada, having on board the parties of Second Lieutenant William E. Rogers, corps of engineers, and Assistant J. R. Mayers; Colonel Farquhar being instructed to continue the reconnoissance for primary triangulation, to the westward of Ontonagon, and connect the off-shore hydrography between Eagle river and former surveys at the head of the lake, besides assisting the shore parties in that locality, keeping them supplied with provisions, &c.

The duty assigned to Lieutenant Rogers' and Assistant Mayers' parties, was that of continuing the topographical and hydrographical survey of the coast, from Pigeon river to the west end of the lake; Lieutenant Rogers commencing at the former point and Assistant Mayers at the latter, and working towards each other.

On the same day, (18th of May,) First Lieutenant James F. Gregory, corps of engineers, sailed on the steamer Search, having on board the parties of First Lieutenant B. D. Greene, and First Lieutenant J. C. Mallery, corps of engineers; the former being charged with the duty of continuing the off-shore hydrography around Isle Royale, &c., bringing supplies to the parties on that island, &c.; the two latter being instructed to complete the topographical and hydrographical survey of the same island, the one being stationed on the south and the other on the north side of the island.

On the same day, Assistant O. N. Chaffee sailed on the steamer Surveyor for duty in White Fish bay, with instructions to complete the triangulation of that locality, as well as the hydrographical and topographical surveys necessary to give a chart of that locality.

The three small parties assigned to the duty of gauging the outflow of the lakes, left this city for their respective destinations on the St. Clair, the Niagara and the St. Lawrence rivers, about the 28th of May, all under charge of Assistant D. F. Henry.

The large instruments ordered from Europe not having arrived up to the 15th of June, and there being no information received as to when they would be shipped, the original programme for the astronomical party was changed, by authority from headquarters, from duty in Lake Superior to determining the latitude and difference of longitude of points on the lower lakes, between this city and Ogdensburg, New York.

This party left this city on the 25th of June, Lieutenant E. H. Ruffner, corps of engineers, in charge; Lieutenant Ruffner first occupying the station at Ogdensburg, Assistant G. Y. Wisner that at Watertown, New York, and Assistant O. B. Wheeler that at Oswego; their instructions being to occupy in succession all the prominent points on the south shore of Lakes Ontario and Erie.

FUTURE OPERATIONS.

The labors of the different parties during the present season will complete the survey of Lake Superior, with the exception of the primary triangulation, (which has been delayed owing to the non-arrival of the instruments ordered for the purpose,) and a portion of the lake in the immediate vicinity of Bayfield and La Pointe, comprising about eighty miles of the south shore, and the Apostle islands. A part of the force will be able to complete this duty during the coming season.

Two fields are open for the future prosecution of the survey. Both are important, and should be surveyed at the earliest practicable period.

The first is the southern portion of Lake Michigan, from Two Rivers on the west, around by Milwaukee, Chicago, Michigan City and the eastern shore to Little Point Au Sable, on the east; all north of these points having been heretofore surveyed.

The chief interest which attaches to this field is the number of important cities and towns that it embraces. But there have been local surveys of nearly all these points, thus in a measure supplying the requirements of a general survey.

The second field is that of Lake Ontario, and the St. Lawrence river as far as the northern boundary of the State of New York.

This field is little known. That portion of it near the outlet of the lake is filled with numerous islands, rocks, and shoals, all of which should be carefully surveyed and plotted for the benefit of commerce.

I am decidedly of the opinion that it is the true policy for the survey of this locality to be commenced as soon as practicable, and prosecuted vigorously until every danger to navigation shall be known.

I would therefore recommend that so much of the force as may not be required in Lake Superior next season should be detailed to commence the survey of Lake Ontario at its eastern extremity, and work from that point down the St. Lawrence to the Canadian line.

Respectfully submitted.

W. F. RAYNOLDS,
Lieut. Col. of Engineers, Brevet Brig. Gen.

Estimate for continuing the survey of the north and northwest lakes, including Lake Superior, for the fiscal year to commence July 1, 1869, and end June 30, 1870, on the same scale and with a similar organization to that at present employed.

For three parties for hydrographical duty, general triangulation, reconnoissance, &c., one for each of the lake survey steamers Search, Surveyor, and Ada, the cost of each party will be as follows, viz:

1 assistant, 183 days, at $4 80 per day....	$880 40	
1 assistant, 183 days, at $3 60 per day....	658 80	
1 assistant, 183 days, at $3 per day.....	549 00	
1 recorder, 183 days, at $1 25 per day.....	228 75	
1 sailing master, 365 days, at $2 75 per day	1,203 75	
1 mate, 6 months, at $60 per month.....	366 00	
1 steam engineer, 365 days, at $2 50 per day	912 50	
1 assistant engineer, 183 days, at $2 per day	366 00	
1 carpenter, 183 days, at $2 per day.....	366 00	
1 steward, 183 days, at $1 50 per day.....	274 50	
1 cook, 183 days, at $1 50 per day.....	274 50	
1 second cook, 183 days, at $1 per day.....	183 00	
4 firemen, 183 days, at $1 25 per day.....	915 00	
14 seamen, 183 days, at 90 cents per day...	2,305 80	
Subsistence for the above 30 persons, 183 days, at 50 cents each per day.....	2,745 00	
450 tons coal, at $8 per ton, (for fuel).....	3,600 00	
Total for one hydrographical party..	15,629 00	
For three parties.....		$46,887 00
For three astronomical, magnetic, and primary triangulation parties as follows:		
1 assistant, 183 days, at $4 80 per day....	880 40	
1 assistant, 183 days, at $2 50 per day....	457 50	
1 cook, 150 days, at $1 50 per day.....	225 00	
5 men for boats' crews and laborers, 150 days, at 80 cents per day.....	600 00	
Transportation of parties, provisions, camp equipage, &c., to and from the field, at $250	500 00	
Subsistence of 8 men, 150 days, at 50 cents per day.....	600 00	
Total for one party.....	3,262 90	
For three parties.....		9,788 70

For five topographical and hydrographical parties to survey shore line and adjacent topography and hydrography, the cost of each party will be as follows:		
1 assistant, 183 days, at $4 80 per day....	$880 40	
1 assistant, 183 days, at $3 60 per day....	658 80	
1 recorder, 183 days, at $1 50 per day.....	274 50	
1 foreman, 165 days, at $1 40 per day.....	231 00	
1 steward, 165 days, at $1 40 per day.....	231 00	
1 cook, 165 days, at $1 40 per day.....	231 00	
1 waiter, 165 days, at $1 per day.....	165 00	
2 leadsmen, 165 days, at 90 cents per day..	297 00	
2 chainmen, 165 days, at 80 cents per day..	264 00	
14 boatmen, 165 days, at 70 cents per day..	1,617 00	
Subsistence of above 25 persons for 165 days, at 50 cents each per day.....	2,062 50	
Expenses in purchase of tools, buoy flags, rope, lead, lead lines, materials for stations, camp and mess equipage, &c.....	600 00	
Transportation of 25 men to and from the field, at $20.....	1,000 00	
Expenses of moving provisions, camp equipage, &c., each way $250.....	500 00	
Total for one party.....	9,012 20	
For five parties.....		$845,06
For three parties for gauging the outflow of rivers, the expense of each will be as follows:		
1 assistant, 183 days, at $3 50 per day....	640 50	
1 assistant, 183 days, at $2 per day.....	366 00	
6 men, 165 days, at $2 per day, (including board).....	1,980 00	
Board of 2 assistants, 165 days, at $1 per day	330 00	
Transportation to and from the field.....	300 00	
Total for one party.....	3,616 50	
For three parties.....		10,84
Office and miscellaneous expenses:		
Office rent and fuel for one year.....	1,800 00	
Pay of two draughtsmen for reducing maps for engraving, one year of 365 days, at $5 30 each per day.....	3,869 00	
4 assistants chiefs of parties, 182 days, at $5 30 per day.....	3,858 40	
2 assistants chiefs of parties, 182 days, at $4 70 per day.....	1,710 80	
2 assistants chiefs of parties, 182 days, at $4 10 per day.....	1,492 40	
1 accountant, 365 days, at $4 10 per day..	1,496 40	
1 accountant, 365 days, at $3 50 per day..	1,277 50	
6 assistants, 182 days, at $3 50 per day....	3,822 00	
1 assistant, 182 days, at $2 90 per day....	527 80	
3 copyists and recorders, 365 days, at $2 50 per day.....	2,737 50	

1 office servant, 365 days, at $1 50 per day.	$547 50	
3 steamers in ordinary, at $1,000 each.....	3,000 00	
Commutation of fuel and quarters for nine officers of the corps of engineers.....	5,000 00	
Traveling expenses of officers and assistants while attending to the duties of the survey	750 00	
Expenses in office, drawing paper and materials, stationery, nautical almanacs, &c..	600 00	
Expenses of meteorological and tide gauge observers for one year.....	4,000 00	
Total estimate for office and miscellaneous expenses.....		$36,489 40
Add 10 per cent. to cover contingent and other expenses, such as purchase of tools, boats, camp equipage, &c.....		14,907 56
Total estimate		163,983 16

Respectfully submitted.

W. F. RAYNOLDS,
Lieut. Col. Engineers and Bvt. Brig. Gen. U. S. A.

Brigadier General A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

W *a.*

REPORT ON THE SURVEY OF THE NORTHERN AND NORTHWESTERN LAKES.

Report of Brevet Lieutenant Colonel Farquhar, captain corps of engineers, upon the determination of the length of the standard bar of the lake survey base measuring apparatus.

UNITED STATES LAKE SURVEY OFFICE,
Detroit, May 11, 1868.

SIR: I have the honor to report that in accordance with your instructions I have made the necessary comparisons for determining the length of the standard bar belonging to the United States lake survey. For determining the absolute length at a temperature of 62° Fahrenheit, there were furnished five yards, whose absolute lengths at the same temperature had been determined in Washington to be respectively as follows: No. 1=36 inches $-\frac{1}{20000}$; No. 2=36 inches $+\frac{2}{20000}$; No. 3=36 inches $+\frac{5}{20000}$; No. 4=36 inches $-\frac{7}{20000}$; No. 5=exact yard. Total=179.99995 inches.

In making the comparisons, (as will be seen by the tabulated result,) the order of the yards was changed three times. From previous experiments, conducted by Assistant Henry, it was thought that the best results would obtain from *suspending* the bar and yards in the oil, instead of supporting them on rollers in the box, owing to the warping or twisting of the box; but it was found that the height of the supporting pins gave rise to vibrations, which the suspending device served to increase to such an extent as to vibrate the work. So, after strengthening and stiffening the box with struts, I did away with the suspending system and supported the bar and yards on rollers. (See accompanying tracing.)

All efforts to obtain *good* results by using a butt piece on one pier and

the comparator on the other failed, for it was impossible to make same contact twice, that is to say, in making a contact between the and butt piece there is a certain pressure. Now on breaking the cont and shifting the box so as to make a contact with the yard and t piece there results a different pressure. Again, the contact being m and the temperature being raised, the bar expands and a greater pres against the butt piece results, and a movement of the butt piece pin t place.

This may appear trivial, but when it is remembered that we are (ing with instruments that are supposed to measure (a movement —.00001 of an inch, and that we found a movement resulting from consecutive contacts of more than —.0001 of an inch, the importan these remarks will be seen. Of course, had the pins been lower and massive such movement would have been lessened. On account o these troubles a second comparator was borrowed and placed on the piece pin. The lake survey comparator measured decimal parts of inch, while the borrowed comparator measured equal parts of some unit. It therefore became necessary, in reducing our observatio determine the value of a division of the second comparator in ter an inch. This was done by measuring parts of the scale of one compa on different portions of the other scale. A mean of 152 observa showed that 100 divisions of the lake survey comparator's scale equal to 92.01 divisions of the coast survey comparator. It may he remarked that although a change in length of the bar of .00001 inch made a perceptible movement in the bubble of the comparato a change of .00009 of an inch might be registered .00008 of an inch, .00 an inch, .00010 of an inch, .00011 of an inch. After passing the .000 of an inch it may well be doubted if the mechanism of Bessel's com tor will accurately measure any smaller sub-division, although any ment of the quill through a smaller space will be shown by a mov of the comparator bubble. The following table gives the results comparisons after proper reduction:

Date.	Number of observations.	Mean result for each day.	Probable error of single observation.	Probable day's o tion.
1868.		*Inches.*	*Inches.*	*Inch*
March 7	10	.00162	.000092	
March 9	15	.00175	.000095	
March 10	5	.00176	.000066	
First order of yards	30	.00169		
March 12	8	.00192	.000071	
March 13	23	.00205	.000096	
March 14	17	.00195	.000112	
March 16	15	.00187	.000093	
March 17	18	.00179	.000188	
March 18	12	.00166	.000063	
March 19	27	.00195	.000093	
Second order	120	.00191		
March 23	24	.00113	.000091	
March 24	18	.00109	.000188	
Third order	42	.00111		
Final result	192	.00171 ±	.000018	longer than

Inches.

The five yards = 179.99995 (See above.)

Length of bar at 62° F. = 179.99995 + (.00171 ± .000018.)

= 180.00166 ± .000018 inches.

Expansion of bar for increase of temperature of 1° F. .00166 in.

Throughout the comparisons I was assisted by Lieutenant J. E. Griffith and Assistant E. S. Wheeler, and the entire reduction was performed by them.

The accompanying sketch (showing plan, side, and elevations and cross-section) fully shows the whole apparatus used in the comparisons. The ends of the yards were held together by strong spiral springs attached to the yards by clamps. The heating apparatus was simple and very effective. The temperature of the oil could be raised from 32° Fahrenheit to 90° Fahrenheit in four hours. When there was any great difference between the temperature of the room and the oil, the conducting properties of the metal scales of the thermometers affected the temperature of the oil about the bulbs. To obviate as near as possible any error arising from this source, the room was kept as near as possible at the same temperature with the oil, especially at the standard temperature of 62° Fahrenheit.

I have the honor to be, very respectfully, your obedient servant,

F. U. FARQUHAR,

Capt. U. S. Engineers and Bvt. Lieut. Col. U. S. A.

Brevet Brig. Gen. W. F. RAYNOLDS,

In charge of United States Lake Survey.

W *b.*

Report on the survey of the northern and northwestern lakes. Description of the base-measuring apparatus and method of using it.

A base line upon which an extended system of triangulation depends should be measured with greater accuracy than can be obtained with ordinary means.

The chief errors in such measurements result from a change of length in the measuring apparatus due to a change of temperature; from the inclination of the measured line to the horizon; and from the shocks which result from bringing one part of the apparatus in contact with another.

To reduce these errors, Professor A. D. Bache, of the Coast Survey, suggested an apparatus which would remain at a constant length during any change of temperature, which would indicate, to a single second, the inclination of the measured line to the horizon, and the two parts of which could be brought in contact with an imperceptible shock.

A similar one made for the United States lake-survey will be here described. The main features are two tin tubes, 10 inches in diameter, and 14½ feet long. Each is supported upon two trestles, so that they can be lowered and raised, moved backwards and forwards, or to the right and left, with great facility. In each tube are two bars, of different metals, so arranged that their unequal expansion keeps two agate points at a constant distance from each other. From each end of the tubes project small steel rods, pointed with agates, which, in measuring, are the points of contact between the two tubes. The length of these tubes is known. In use they are placed end to end upon the line to be measured, the two agates touching each other. The forward one is left standing, while the rear one is carried forward, and the agates again brought together. This is continued until the whole line is measured, when the whole number of tubes is multiplied by the length of one tube, which gives the whole length of the line.

Such is the outline. The details will now be given, beginning w the compensating part, which consists of two bars, A and B, figur A is iron, and B brass. Their length is about 14 feet; their other dim sions are shown in figure 6. Their cross sections differ; their relat area and perimeter were determined by ProfessorBache, who, "by nu rous experiments in 1845 and 1846, so arranged them that the two b might have equal absorbing surfaces, while their masses were inver as their specific heats, allowance being made for their different cond ing powers. Thus while each receives the same accession of heat i given time, the temperature of the two will continue equal. The s varnish on both surfaces gives them equal absorbent powers."

The bars are placed edge to edge, the iron above the brass, with ab one-third of an inch between them. They are kept in place by an i frame-work and butting screws, a section of which is shown at A, fig 6. The brass bar rests on small steel rollers, as shown at F, figur which keeps it straight, and allows it to move backwards and forwa easily. There are also similar rollers placed between the bars to k them parallel. At one end they are firmly fastened together by be bolted to a butt-piece of steel, shown at A, figure 2. At the other is the compensating lever, shown at C, figure 1. A projecting kn edge, D, presses against a plate of hardened steel attached to the i bar. The spiral spring E keeps the lever in place. F is a steel r which slides easily in its supports, PP. The expansion of the iron pushes it forward, but the greater expansion of the brass bar at same time draws it backwards an amount sufficient to compensate the increased length of the bars.

When not in use the lever is pushed forward so that the knife edg clear from the steel plate and kept in that position by a block inse between P and O. To compute the length D H when I D is given–

Let l=I D.

Let a=expansion of brass bar.

Let b=expansion of iron bar.

Let x=D H.

The expansion of the brass bar will draw the rod back a distanc $a\frac{x}{l}$.

The expansion of the iron bar will push it forward a distance=$\frac{b(}{}$

but these two must be equal if the bars are compensating, hence

$ax=bx+bl$

from whence $x=\frac{bl}{a-b}$=D H.

This value was obtained for the first tube by trial. The second was then made exactly like the first, but did not prove to be compe ting, probably owing to the different densities and consequent diffe rates of expansion of the bars.

The value of D H for the second tube was finally determined by ex iments.

K, Fig. 1, is an agate with a plain polished surface upon which tact with the forward tube is made. There is also shown a section the cap which protects this agate when not in use.

The compensating apparatus is surrounded by three concentric tu The outer and middle ones shown at L are of tin, with a space three-fourths of an inch between them, forming a partial non-conduc of heat which tends to keep the temperature within uniform. The in one shown at N is made of boiler iron, and gives strength and stiffn

to the whole tube. The manner in which the compensating apparatus is fixed in this tube is shown in Fig. 6.

At the other end of the tube is the contact level, an ingenious contrivance which enables the ends of the two tubes to be brought together without a perceptible shock.

E, Fig. 2, is a Bessel level turning about the pivot E. The right-hand end is loaded so that it will drop down if not supported.

D is a steel rod supported by the pieces B C and H F, which allow it to move backwards and forwards, but keep it constantly parallel to the brass bar and its first position.

Its right-hand end is hard and pointed and presses against I, which is a piece of polished steel made concave with a radius equal to R I. I is attached to the lever K, which presses against an arm of the contact level as shown in the figure.

If there is no pressure on the left-hand end of the rod the heavy end of the contact level will drop, pushing the lever and the rod forward.

If in this position the ends of the two tubes be brought together and the forward one pushed slowly towards the rear one, the rod will exert but a very slight pressure on the rear tube, but will move to the right, bringing the contact level to a horizontal position. When this is done the tubes are said to be "*in contact.*"

The agate L at this end of the tube is ground to a knife edge and is brought in contact with the agate of plain surface on the rear tube.

When not in use the agate is protected by a cap, a section of which is shown in the figure, and the loaded end of the contact level is pressed down upon a bunch of cotton and kept in that position by means of the screw shown at P.

The sector level determines the angle which the tube makes with the horizon. It is shown at M. It turns freely in a vertical plane around the point B. V is an arc of a circle graduated to 10 minutes, and reading to 10 degrees each side of the zero point. The vernier plate in the figure is removed to show the works behind it, but the dotted lines show its position. S is a micrometer headed screw with a reel thread turning in the cogged edge of the graduated limb, giving it its vertical motion. A revolution of the screw moves the graduated circle over 10 minutes.

The micrometer head is divided and estimated into 600 equal parts, therefore each part represents a second. These graduations are numbered in two places, one reading to the right and the other to the left. The former is used when the zero of the limb is above, and the latter when it is below the zero of the vernier.

The degree and even 10 minutes are read from the graduated limb; the remaining minutes and seconds are read in seconds from the micrometer head, and afterwards reduced to minutes and seconds.

The screw is pressed against the limb by a spring shown at O. T T are capstan headed adjusting screws which move the level through a small arc independently of the graduated limb.

A slow longitudinal motion is communicated to the bars by the screw shown at N.

It is with this screw that the final delicate operation of "making the contact" is performed.

The nut in which it turns is connected with a point directly over the rear trestle by a compensating apparatus shown in the figure.

This apparatus is made much shorter in the drawing than it really is in order to show both ends of it, and also the spiral spring Q, which is intended to prevent back lash in the contact screw.

Each tube is supported upon two trestles. The forward one has two legs, and the rear one three.

A side view of them is given in Figs. 3 and 4.

These trestles are capable of communicating vertical, lateral, and longitudinal motions to the tubes. They are also so arranged as to produce the vertical and longitudinal motions in two ways; one called the rapid and the other the slow motion. The former used in bringing the tubes nearly into position, while the last delicate movements are made by the latter. The manner of producing these motions will now be given in detail, beginning with the rapid vertical motion of the rear trestles. This is effected by a rack and pinion shown at O, Fig. 5, which moves the cylinder A (and with it the tube) up and down in the hollow cylinder E, shown in section. The rapid vertical motion of the forward trestles is effected in a similar manner.

It will be seen by reference to the figure that the cylinder A is hollow at the upper end, and another cylinder C D is screwed into it. If C D be revolved the action of the screw will produce a vertical motion. This is called the "slow vertical motion."

The method of revolving the cylinder C D is best seen in Fig. 4. A is a rod convenient to the hand of the operator and connected by the universal joint F to the small bevel wheel C, which works in the large bevel wheel E, and thus communicates a slow rotary motion to D.

The slow vertical motion in the forward trestles is similar.

The rapid longitudinal motion is effected by the screw H, Fig. 4, which moves the plate I, and with it the tube backward and forward through a small space. This plate slides upon another plate, K, and is kept in position by two tongues which slide in grooves made in the edges of the lower plate as shown at K, Fig. 4, and N, Fig. 5.

The forward trestle has no longitudinal motion of its own, but inclines backward and forward as the tube is moved. The slow longitudinal motion is not effected by the trestles, and has been previously described.

The lateral movement is effected by the screw I, Fig. 5, which moves the plate D to the right and left on the bed-piece M, to which it is attached by a tongue and groove as before described. For the convenience of the operator the rod B, Fig. 4, which turns the screw I, passed back to the rear end of the tube. To do so it has to turn a right angle. This is accomplished by having a portion of the rod a spiral spring shown at H, Fig. 5, and L, Fig. 4.

This spring is bent into a quarter of a circle, so changing the direction of the rod 90 degrees.

The lateral movement of the forward trestle is the same as that of the rear one, except the screw is turned by a crank shown at B, Fig. 3, instead of a rod.

Fig. 11 is a horizontal projection of the cast-iron bed piece which supports the rear trestles.

N, Fig. 4, is a vertical projection of the same. There are two sets of these, so that one may be placed and leveled while the tresties are on the other. Fig. 12 is the horizontal projection of the level used in leveling the bed-piece.

Figs. 9, 10, and C, Fig. 3, are the corresponding projections for the forward bed-piece and level.

The devices for leveling the bed-pieces are shown at O, Fig. 4.

Figs. 7 and 8 are the vertical and horizontal projections of the comparator, an instrument used in comparing the length of the tube with that of the standard bar. It is of such delicacy that an interval of one hundred thousandth of an inch can be measured by it.

A, Fig. 7, is a Bessel level, similar to the contact level. It is moved backwards and forwards one inch by the micrometer screw B.

C is a brass cylinder, called a quill, resting on the rollers D.

A, Fig. 8, is a vernier, reading to fiftieths of an inch. B and C are spirit levels. E E are screws which fasten the comparator to its support.

To read the comparator, suppose the quill to be fixed in the position shown in the figure. The micrometer screw is turned to the right, pushing the arm of the level against the quill until the bubble is nearly in the middle of the level.

A division of the micrometer head is then made to correspond with the index at E.

The reading is now taken: the tenths and hundredths are read from the vernier at A, Fig. 8; the thousandths and ten thousandths are read from the micrometer head; and half the difference of the reading of the two ends of the bubble gives the hundred thousandths.

The vernier is divided into fifty equal parts, and the micrometer into two hundred. This makes it necessary in reading to add one to the hundredths when the micrometer reading is one hundred or more, and take only the last two figures of the micrometer reading for the thousandths and ten thousandths.

The standard bar is of brass, very nearly 15 feet long, 1¼ inch wide, and one-quarter of an inch thick, with an agate firmly imbedded in each end.

Its length, at a temperature of 62°, was first determined by comparing it with five standard yards, at Washington, numbered 43, 44, 45, 46, and 47.

The comparator posts are made of stone, in two parts, for convenience of transportation, and are shown in the sketches at the right and left of Fig. 8. The two parts are fastened together by an iron bolt which passes through the lower one and into the upper one, where it is keyed through a transverse key-hole.

It is packed with India-rubber, to prevent its contraction from breaking the stones.

The complete post is five feet high, and weighs 1,600 pounds.

They are set 15 feet apart, upon a solid foundation. The comparator is firmly fastened to the top of one of them.

From the side of the other one, on a level with the quill, projects a butt-piece of steel one-half an inch long, with a polished and slightly convexed end. Between these posts are placed two trestles.

To adjust the section level, the agates at both ends of the tube are brought into the same horizontal plane. This is done with an ordinary level set on a post at a convenient distance from the tube. A post is used because the tripod is not generally steady enough.

The tube being level, the graduated arc of the section is made to read zero by turning the micrometer screw.

When this is done, if the micrometer head does not also read zero, it is pushed back until the thread is free from the cogs, when it is turned until it does. It is then allowed to spring back to its original position. The bubble is then brought to the center of the level with the adjusting screw T, Fig. 2.

To find the value of a division of the sector level the graduated limb is read when the bubble is near one end of the level; the micrometer screw is then turned until the bubble is near the other end, when a second reading is taken. The difference of these two readings, divided by the number of spaces through which the bubble passed, is the value of a single division. The mean of a great number of results is *three seconds*.

In use this bubble can generally be brought to the center, but it is sometimes more convenient to simply bring both ends in sight, take half the difference of their readings, multiply it by 3; and, 1, if it be down grade and the bubble to the right, subtract the result from the seconds of the grade-angle; 2, if down grade and bubble to the left, add; 3, if up grade and bubble to right, add; 4, if up grade and bubble to left, subtract.

In use it is not convenient to bring the bubble of the contact level to the center, but simply so that both ends of the bubble are visible, when half their difference is taken and multiplied by the value of a single division, and the result added, with the proper sign, to the length of the tube. It is necessary then to know the value of a single division of the contact level.

To find it, a tube is placed between the comparator posts, with the comparator at the forward end. Contact is made with the butt-piece, so that the bubble is nearer one end of the level than the other. The ends of the bubble and the comparator are then read at the same time.

Contact is then made, so that the bubble is nearest the other end, when another reading is taken.

The difference of the comparator reading is then divided by the number of spaces over which the bubble passed.

The result is the value of a single division. The mean of a large number of these results is .000015 inch.

To determine the amount which the standard bar expands for one degree of heat, the bar is placed between the comparator posts; six thermometers are placed at equal distances along and in contact with it. The thermometers and comparator are then read. After the temperature has changed through several degrees, another set of readings are taken.

The difference of the comparator readings is divided by the difference of temperatures.

The quotient is the expansion of the bar and quill due to one degree of heat, called the "coefficient of expansion." The mean of a great number of results is .00188 inch.

(The expansion of the quill is determined in a similar manner. Its coefficient is .00004 inch.)

To compare a tube with the standard bar, the trestles and comparator posts are fixed the same as for comparing the bar with the yards. The tube is placed on the trestles and the bar laid on the tube, great care being taken to keep it perfectly straight. Six thermometers are placed along and in contact with it. The bar and tube are brought alternately between the butt-piece and quill by means of the vertical motion of the trestles.

The bar is first brought in contact with the butt-piece and the thermometer read.

Then the comparator is read three times in succession, the contact of the quill being broken between each reading; after which the thermometers are read a second time. The difference between the mean of their readings and 62° is multiplied by the coefficient of expansion, and added, with the proper sign, to the comparator reading; the result is what the bar would have read if the temperature had been 62°.

The tube is next brought between the butt-piece and quill. The operator at the rear end now turns the contact screw until both ends of the bubble in the contact level are visible. In the same time the operator at the forward end prepares the comparator for the reading. When

both are ready a signal is given, and the readings taken simultaneously, the one at the rear end simply reading both ends of the bubble.

Half their difference is multiplied by the value of a division of the contact level, and added, with the proper sign, to the comparator reading; this gives what the comparator would have read if the bubble had been in the middle. This is repeated three times and the mean taken. The correction for the expansion of the quill is applied in the same manner as for the bar. The corrected reading of the tube is subtracted from the corrected reading of the bar. The remainder is the amount which the tubes is shorter than the bar at a temperature of 62°. But the length of the bar at this temperature is known; hence the length of the tube becomes known.

The mean of sixteen comparisons is considered sufficiently exact. Not more than ten thousand feet is measured before the tubes are recompared, for, in spite of every precaution, their lengths change with use. When these comparisons are made in the field the comparator posts are protected by a temporary building.

The following table shows the method of keeping the notes. It is copied from the notes of comparison made on the Keweenaw base line, Lake Superior, 1866:

Description.	Thermometer.						Contact level.	Comparator.	Cor. for tem.	Cor. reading for bar and tube.	Bar larger than the tube.
	1	2	3	4	5	6	.....	.....	.....	.....	*Inch.*
	630	630	631	628	624	630	.....	0.41455	.....	.....	
						mean.					
Bar	.....	.....	.....	.....	.....	6297+	.....	0.41456	0.00235	0.412230	
	633	631	632	630	625	630	.....	0.4145 4–5	.....	.....	
	.....	.....	.....	.....	.....	.....	1817	0.40121	.....	.....	
Tube No. 2.	.....	.....	.....	.....	.....	.....	1421	0.40120+	17	0.40120	0.01110
	.....	.....	.....	.....	.....	.....	1718	0.401 14-18	.....	.....	
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	637	634	635	632	629	633	.....	0.41474	.....	.....	
						mean.					
Bar	.....	.....	.....	.....	.....	6336+	.....	0.41470	0.00232	0.41239	
	638	635	635	633	630	633	.....	0.41468	.....	.....	

To use this apparatus successfully a base line is selected over hard and firm ground, where there is no grade of more than three degrees. The stumps, stones, and loose soil are all removed for a width of 15 feet, and the ground firmly packed. At one extremity of the line a stone four feet long is set its whole length in the ground. In the top of the stone is a brass bolt. Across the head of the bolt are drawn two fine lines; their intersection is the initial point. After the line is measured, its other extremity is marked in a similar manner. Stations are built over these points.

To measure the line, the first thing that is necessary is to bring the rear end of the first tube directly over the initial point. This is a delicate operation, requiring much care. There are several ways of accomplishing it. One is, to place the second tube on the side of the starting point opposite to the direction in which it is intended to measure. A transit is set up on the line about 1,000 feet distant. The intersection of the cross hairs is brought on the initial point; the telescope is then elevated and the agate brought into the intersection of the cross hairs. The agate is now in the line.

Next, a second transit is set up opposite the starting point and at right-angles with the line. The point of a sharp knife or needle is

placed at the intersection of the lines on the head of the brass bolt. The second telescope is sighted at this point, and then elevated to the agate, which is then brought up until it is tangent to the cross hairs. It is now directly over the initial point. The first tube is now brought up and placed in line by the observer at the transit. The operator at the rear end of the first tube brings the bubble to the center of the sector level by means of the micrometer screw. He then makes the contact, and reads, first, the two ends of the bubble in the contact level; then the grade-angle from the graduated limb; and, finally, the three thermometers that are placed in the middle and ends of the tube.

The second tube is now by the longitudinal motion of its trestles drawn backwards away from the first until the contract is broken. It is then carried forward a length and brought in contact the same as the first. Then the first is carried forward, and so on until the day's work is closed. To mark the point where the day's work closes a stone similar to the one at the starting point is placed precisely under the end of the tube in the same way that the tube was placed over the first one.

There are two ways of carrying the tubes. One is to carry the tube and trestles together by the handles shown at L, Fig. 5; the other is to carry the tube separately by the handle shown at K. The latter is preferable. Four men are required in either case.

The following table shows the method of keeping the notes when the line is being measured. They were copied from the notes of the Keweenaw base line, Lake Superior, 1866.

Tuesday, October 2, 1866.

Time of day.	Whole No. of tubes.	No. of the tube.	Contact level.	Inclination.		Thermometer.				Remarks.
						1.	2.	3.	Mean.	
h. m.				° ′ ″						
1 14	1	2	19.18	2 1 5.19	Fall.	54.8	54.0	54.7	54.50	Started from south end of base-line.
1 23	2	1	11.17	2 50 3.12	Fall.	55.9	55.7	55.9	55.83	
1 29	3	2	17.20	0 30 5.80	Fall.	57.0	54.6	55.3	55.63	
1 49	4	1	13.15	0 20 1.90	Fall	59.5	56.3	56.8	57.53	Sky overcast; wind light from southwest.
1 57	5	2	16.20	2 30 2 68	Fall.	62.0	57.5	57 8	57.40	
2 05	6	1	12.15	2 20 1.68	Fall.	60.3	56.2	57.4	59.10	
2 13	7	2	11.25	2 10 0.11	Fall.	61.0	57.8	58.0	58.90	
2 22	8	1	15.13	3 40 1.58	Fall.	58.5	56.3	57.0	58.93	Ground poor; tubes shake badly.
2 29	9	2	22.14	2 10 4.74	Fall.	57.4	57.0	57.0	57.26	
2 39	10	1	12.15	1 00 5.88	Fall.	56.6	53.4	55.8	57.13	

The thermometers were read so that if the tubes should prove to be not quite compensating they could be corrected for temperature. When the end of the line is reached a stone is placed under the end of the last tube in the same manner as at the close of a day's work, and the line consists of an even number of tubes. But if the extremities of the line be established before it is measured the distance between two given points has then to be determined. This distance consists of a certain number of tubes and a fractional part of a tube. As there is no way of measuring a part of a tube it must be computed. A convenient way of doing this is shown in the figure opposite. Let A be the end of the line and A D the part of the tube to be computed. Some known point in the line, say at B, 500 or 600 feet from D is taken and with D B for a base the triangle D B C is computed, then with B C for a base the triangle A B C is computed and A D becomes known. [For diagram see original.]

After the measurement is completed the horizontal distance between

the ends of the line is completed. It is equal to the sum of the horizontal projection of all the tubes. The horizontal projection of a single tube is equal to the length of the tube multiplied by the cosine of its grade angle. When there are 1,500 or 2,000 tubes to compute, the easiest way is to form a table of the length of a tube for each ten seconds of grade angle up to three degrees. The horizontal projection of each tube is then taken directly from the table and their sum is the length of the base line. A portion of the base is generally remeasured to test the accuracy of the work. This is a case where the distance between two given points is required, but here the practical part of a tube is always less than an inch, hence it can be measured with the comparator.

W *c.*

Report on the survey of the northern and northwestern lakes.

OFFICE LAKE SURVEY,
Detroit, July 1, 1868.

SIR: I have the honor to submit the following report on the measurement of the base line at L'Anse bay, Lake Superior. This line I selected in the fall of 1865, and it was cut out and grubbed that fall and the following spring. In the fall of 1866, I went there by your orders, and commenced the grading and measurement, but on account of the wet weather was only able to measure about 4,000 feet. In August, 1867, three shore parties were sent there, and on the 27th I landed to recommence the measurement. After having made the necessary preparations and comparisons of the tubes with the standard bar, on the 7th of September I began measurement at the south base station.

The rear agate of the first tube was brought in contact with a silk plumb line suspended from the center of the station, the point of the bob, (of about five pounds weight,) being over a point in the top of a small triangular brass leaded into the top of a stone five feet long, sunk about six inches below the surface of the ground. The measurement was continued to the 768th tube, when, having to stop to let the grading parties get ahead, the tubes were taken back to camp and comparisons again made with the standard bar, the comparison stones being set up in a house in camp, could not well be moved down the line.

The measurement was again commenced on the 1st of October and continued to the north base station, beneath which a similar stone to the one under the south base station, was sunk, and connected with the front agate of the last tube. The tubes were carried again to camp and another set of comparisons made with the standard bar. The results of these several comparisons are given below:

	Inches.
Length of standard bar	180,001.66
Length of tube 1, first comparison	179,985.21
Length of tube 1, second comparison	179,985.24
Length of tube 1, third comparison	179,984.14
Length of tube 2, first comparison	179,992.47
Length of tube 2, second comprison	179,992.07
Length of tube 2, third comparison	179,992.18

The sector level was connected in each tube at the time of making the first comparisons and at the second an error of 36 inches rise was found

in tube 1, and nothing in tube 2. Again being adjusted the error at the last comparison was 43 inches fall in tube 1, and 48 inches fall in tube 2.

A station was built near the center of the line at the end of the 952d tube for the purpose of testing the measurement. This station was afterwards found by means of the repeated angles made for the triangulation to be less than a quarter of an inch off of the line between the north and south base stations.

Stones four feet long were sunk at least a foot below the surface at the ends of tubes 303, 588, 952, 1271, and 1600, respectively, the vertical line passing the end of the agate being marked by a point at the intersection of two lines across the top of a triangular brass leaded into their upper surface.

The apparatus and mode of measurement were the same as described in my report on the Chambers Island base, except that two extra trestles and foot-plates were furnished. These were set up in front of the tubes, and by means of a wooden gauge brought nearly into line, so that much time was saved in leveling and lining the tubes, as well as making the work easier and better.

A great many stoppages had to be made to enable the grubbing parties to keep ahead of the measurement, and also on account of the wet weather. Stakes had to be driven under the corners of nearly half the foot-plates, the ground being wet and soft. This will account, also, for the few hours in each day during which work was done, as shown in the table, and also for the length of average time per tube. The number of tubes measured in one hour over good ground exceeded by one-half what we had been able to accomplish with the apparatus heretofore. If the line should be remeasured in the dry season, it could be done in 10 or 12 working days, and in a much more satisfactory manner.

The following table shows the number of hours per day, the working days, the number of tubes measured, and the average time per tube:

Date.	No. of hours worked.	No. of tubes.	Average time per tube.	Date.	No. of hours worked.	No. of tubes.	Average time per tube.
	h. m		m. s.		h. m.		m. s.
September 7	2 29	23	6 29	October 12	6 43	79	5 06
September 9	4 29	63	4 15	October 14	1 16	20	3 48
September 10	7 02	114	3 42	October 15	4 42	81	3 29
September 11	8 10	103	4 45	October 16	6 03	92	3 58
September 12	5 41	113	3 11	October 18	5 10	71	4 22
September 13	4 50	77	3 46	October 19	7 04	85	4 58
September 14	6 30	95	4 06	October 22	6 43	112	3 36
September 20	5 31	72	4 36	October 23	5 11	79	3 56
September 21	7 22	108	4 06	October 24	5 52	81	4 21
October 1	6 33	125	3 09	October 25	5 33	61	5 27
October 3	5 47	108	3 13				
October 7	7 30	88	5 07		132 31	1,933	4 22
October 8	6 20	83	3 35				

I append a sketch of the position of the base line and of the first triangles, showing the expansion from the base. It will be noticed that the system is so arranged that the principal lines are determined by two separate sets of triangles. This was carried out as far as possible in the selection of all the points of the main triangulation, so that the line north from Vulcan station across the lake was twice determined.

I also give a profile of the line. This shows that there are no sudden elevations in the line, making most of the work in grading the removal of the surface soil. This would have been easy in a dry time; but the

continual rains filled up the hollows, and made the removal of the muck quite difficult and tedious.

I was ably assisted in the measurement by Assistants E. S. Wheeler, D. Wallace, Mr. K. Havens, and Mr. John Whitting; and I take this opportunity of returning my thanks to them for the careful and efficient manner in which they performed their several duties.

The computations of the length of the base line are being made, and will, I presume, be reported directly to you.

I have the honor to be, very respectfully, your obedient servant,

D. FARRAND HENRY.

Bvt. Brig. Gen. and Col. W. F. RAYNOLDS,
Corps Eng. in charge Lake Survey, Detroit.

W *d.*

Report on the survey of the northern and northwestern lakes.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, July 1, 1868.

SIR: I have the honor to submit the following report of progress of the river-gauging parties under my charge:

On the accompanying map of the north and northwestern lakes it will be noticed that the chain is but an expansion of the connecting rivers; and that after leaving Lake Superior, and coming down the St. Marie river, we have Lake Huron, with Lake Michigan, on one side, and Georgian bay on the other, which appear to be merely expansions to the east and west; then a long stretch of river, the St. Clair; next Lake Erie, turning to the eastward; then Niagara river, turning sharply to the north; and lastly, Lake Ontario and the river St. Lawrence. Thus the chain is naturally divided into four sections, with outlets which can be measured.

The first thing was to find the place in these outlets where the depth was most uniform, and the banks nearly parallel. As all the outlets, except the St. Lawrence, had been surveyed, there was not much difficulty in choosing these points.

FOR LAKE SUPERIOR.

1. The St. Marie river, above the rapids, is tortuous and uneven, and about five miles below divides into two branches. At Point aux Peris, above the rapids, the river is quite narrow, and the cross-section is comparatively regular, but for so short a distance that it was impossible to find a good base-line. About a mile below the rapids the banks are nearly parallel for about 1,500 feet; and though somewhat broken by rocks and shoals, the bottom is pretty even. The latter place was therefore chosen.

2. In the St. Clair river, the outlet of the second section, the best place was found near St. Clair, where, though the river was somewhat wider than at other points, the cross-section was most uniform.

3. In the Niagara river, the flow above the falls is much disturbed by rocks and shoals, and below there are eddies and back flows all the way to Lake Ontario. The place where these eddies were narrowest was found to be about three miles above its mouth, the back flow being only about 50 feet wide on each side of the river.

4. At Ogdensburg, on the St. Lawrence, the outlet of the whole chain of lakes, the water-shed of the lakes, shown on the map, seems to converge; and also, about five miles below the town, the rapids commence, while the last of the Thousand Islands is about 12 miles above.

The river is quite wide and the current slow, but the bottom is very even and regular. A point a mile above the town was therefore chosen as the fourth station.

Sketches showing the outline of the river and soundings at each of these places are given, Figs. 1 to 4, and cross-sections at the places where the gauging was done in Figs. 5 to 8.

The method of operations was the next question. This was also easily decided, for the short time I had for preparation and the want of practical knowledge of this kind of work made the adoption of some system of the measurement of the velocity by means of floats necessary; and that perfected by Captain Humphreys and Lieutenant Abbott, topographical engineers, in their gauging of the Mississippi, seemed to be the most rational as well as scientific; and in fact was the first attempt to measure so large a body of water. That method, as described in their Report on the Physics and Hydraulics of the Mississippi River, &c. (prepared by Captain A. A. Humphreys and Lieutenant H. L. Abbott, topographical engineers,) p. 224 *seq.*, is as follows:

> Two parallel cross-sections of the river having been made 200 feet apart, a base line of the same length was laid off on the bank perpendicular to both. * * * An observer with a theodolite was stationed at each extremity of the base line. It is evident that when the telescopes were directed upon the river with their axes set at right angles to the base line, the vertical cross-hairs mark out the lines of sounding upon the water surface, and that the time of passage of a float between these lines was that consumed in passing 200 feet. Also that if the angular distance of a float from the base line when crossing each line of sounding was measured, its distance in feet from the former could be readily computed and its path fixed. Upon these principles the observations were conducted.
>
> Two skiffs were stationed on the river, one considerably above the upper and the other below the lower section line, the former boat being provided with several keg floats. At a signal from the engineer at the upper station, whose telescope was set upon the upper section line, a float was placed in the river. The keg immediately sunk to the depth allowed by the cord and the whole float moved down toward the upper line. The observer at the lower station followed its motion, keeping the cross-hair of his telescope directed constantly upon the flag.
>
> At the word "mark" uttered by his companion when the float crossed the upper line, he recorded the angle shown by his instrument, and then setting his telescope upon the lower line watched for the arrival of the float. In the meantime the observer at the upper station, whose theodolite supported a watch with a large second hand, recorded the time of the transit of the float across the upper line and then followed the flag with his telescope.
>
> At the "mark" given by his assistant when the flag crossed the lower line he recorded the time and angular distance from the base line.
>
> The float was picked up by the lower boat. The floats mentioned above were double, that is, consisting of a lower part whose specific gravity was a little greater than water, and connected by a cord with an upper float which rested on the surface of the water and held the lower part at any depth wished. The best kind were found to be for the lower part paint kegs 12 inches in height by 8 inches diameter and a surface float of tin of an ellipsoidal form, the axes being 5.5 and 1.5 inches, connected by a cord less than one tenth of an inch in diameter.
>
> The size of the keg was so much greater than that of the surface float that the latter did not sensibly affect the rate of movement. Through the center of the surface float a wire was passed projecting about one foot and bearing a small flag.

Simultaneous observations should have been made at each of the four places; but as it was not possible to send out but two parties, I established water gauges at the other two points, that tri-daily readings of the height of the water might be taken while observations were made at the other points, and the discharge at the several places could thus be compared.

Similar daily records of the height of the water having been kept at various places on the lakes for nearly eight years, the general fluctuations were known and could be used in the comparisons.

On the 7th of June I left Detroit for St. Clair with both parties, one under the charge of Assistant A. R. Flint, assisted by Mr. Wm. Graham, and the other under charge of Assistant L. Foote, assisted by Mr. P. Hunter, to establish the best mode of working and to familiarize ourselves with it.

The base line taken by General Humphreys was 200 feet, as before stated, that being the greatest distance a person could hear distinctly on a still day, and I found that even then the wash of the waves on the beach, caused by the constant passage of boats and other common noises, made considerable exertion of the lungs necessary. Besides, the practical difficulty of calling loudly at the time of watching the float and recording the time made it very uncertain.

The St. Clair river at the place chosen was about 1,700 feet wide, and this made the work from so short a base line inaccurate, for the angle a float at the further side of the river would make with its ends would be less than 7° and at the center only about 15°, making the plotted position of the distant floats very uncertain.

I therefore concluded to put my stations further apart and to connect them by telegraph.

I selected a base line nearly 700 feet long and set up at each end solid posts, sinking them about four feet in the ground, for the theodolites to set on.

Near each of these posts, but not touching, I put another post on which were placed a relay or sounder and a talking key, and on the one at the upper station a chronometer. The two stations were then connected by a wire with each other and with a small battery.

On the opposite side of the river two flags were set up so that the lines joining them and the opposite station of the base would be perpendicular to the direction of the current.

Then a float being set off from a boat anchored far enough above the upper station to allow it to assume a uniform motion and at any desired distance from shore, the assistant at the upper station directed the telescope of his instrument on the opposite flag.

Just as the float reached the field of his glass he gave an alarm with his key and caught the beat of the chronometer.

Then, with his hand on the key and counting the chronometer beats, he watched till the float reached the vertical cross-hair of his instrument, when he closed the circuit noted and recorded the time. The assistant at the lower station at the first alarm turned his telescope upon the float and followed it until the single tick showed him it had reached the upper line; he then read and recorded the angle, and turned his telescope upon the lower flag. He in turn as the float approached the line gave the alarm and the single tick as it passed, and the first assistant at the alarm turned his telescope upon the float, and counted the chronometer beats until the tick informed him that the float was passing the lower line, when he noted the time and recorded it together with the angle.

In this manner the time of passage of the float was obtained to the nearest second, and the position within a foot.

After a series of floats had been put out at different depths, the boat was moved to another part of the river and another series taken.

The lower part of the float was an old paint keg with the bottom knocked out and with a reel inside of it, with as much small cord about one-tenth inch in diameter as was necessary wound upon it. This cord was marked every five feet and passed up through a small hole in a leather strap riveted on the top of the keg. The tin ellipsoidal floats

had a wire running through the center projecting four inches below and eight inches above, and having on the lower end an eye to which the cord was fastened.

This wire carried a flag of red flannel about two inches wide and six inches long. I noticed that even this small flag seemed to have an undue influence upon the direction of the float, particularly when it was accidently wet, and I therefore tried the small red India-rubber balloons filled with hydrogen gas and with air, letting them float about one-half or one-third their diameter above the surface. These did very well in perfectly still water, but if a wave struck them they would burst with the increased pressure.

I also tried small tin cylinders and cones on the top of the floats. At certain times of the day they would show beautifully, but for general use they were not as good as the flags. But another use was found for them which facilitated operations considerably.

The floats often being 10 minutes in passing, it was found advantageous to start them from the boat one or two minutes apart, until the first one had reached the lower line. The instruments were thus kept nearly in the same position until the floats had crossed the upper line, and then both were turned upon the lower till the whole group had passed. But sometimes one float would overtake and even pass another, being at different depths, and therefore there was a liability of error; but by putting out different kind of floats, it was always known which started first, and they did not need to be watched all the way down.

The soundings for the cross-sections were made with great care, on both the upper and lower line. They were taken generally with a 20 pound lead attached to a jack chain, on which the fathoms were marked by small brass tags, the feet being measured by a rod in the boat. Each sounding was located in the same manner as the floats, by both instruments.

After we had become familiar with these operations, Assistant Foote and party were sent up to the St. Marie's river, and Assistant Flint left at St. Clair. On the 20th of July, Assistant Flint and party went to Ogdensburg, on the St. Lawrence; and on the 10th of August, Assistant Foote and party to the Niagara river, where they remained until the last of September.

The work on the St. Marie's and Niagara rivers was conducted in the same manner as that described above, but at Ogdensburg the St. Lawrence was so wide, over 7,000 feet, that a base line was taken on each side of the river 1,117 feet long, and the work carried to the middle from each way.

At each place, while the parties were at work, meteorological observations, including the height of the water, were taken every two hours, and at other times tri-daily.

The stage of the water at the several places is given in the following table, the figures showing the height of the water below the high water of 1838, comparisons of the zeros of the gauges being made in the manner explained in my report on the meteorology of the lakes. As I have remarked in that report, though the general level of Lake Ontario through a series of years is about the same as the other lakes, yet there are at times quite large differences between them.

The following table shows that that lake rose during the past season over a foot higher than Lake Erie or Lake Huron, and nearly reached the highest stage of water known—that of 1838:

Table of bi-five day means of the height of the water for the several places of observation, 1867.

Date.		Water below the high water of 1838.			
		St. Ste. M.	St. C.	Niagara.	Ogdensburg.
June	16 to 25	.....	2.10	0.42	.....
	21 to 30	.....	2.08	0.46	.....
	26 to 5	.....	2.08	0.54	.....
July	1 to 10	2.45	2.05	0.60	0.27
	6 to 15	2.25	2.00	0.64	0.31
	11 to 20	2.23	1.99	0.64	0.49
	16 to 25	2.24	1.91	0.63	0.62
	21 to 31	2.17	1.99	0.62	0.61
	26 to 5	2.14	2.09	0.60	0.76
Aug.	1 to 10	2.09	1.94	0.58	0.77
	6 to 15	2.14	2.02	0.50	0.88
	11 to 20	2.14	2.02	0.38	1.02
	16 to 25	2.11	2.05	0.34	1.12
	21 to 31	2.11	2.12	0.41	1.19
	26 to 5	2.15	2.26	0.53	1.24
Sept.	1 to 10	2.15	2.24	0.69	1.50
	6 to 15	2.10	2.17	0.80	1.54
	11 to 20	2.11	2.34	0.90	1.61
	16 to 25	2.09	2.33	1.00	1.69
	21 to 30	2.13	2.34	1.04	.....

For facilitating the plotting of the work in the field, the following method was adopted:

The length of the base line, and the distance from each station to its opposite flag being known, these lines were plotted on a large scale, 100 feet to an inch. A table was then computed for each station, giving the departure for each degree and parts of a degree of a line revolving on one of the stations as a center, and cutting a perpendicular to the base line through the other station. With this table the position of both ends of the path of any float was easily plotted on the cross-section lines by means of a scale alone.

Separate sheets were plotted each night for every five feet of depth, and from them it was readily seen where more floats were needed in the next day's operations. The positions of the soundings were plotted in the same manner.

In the office the same method was followed. The base lines used in the gauging were connected by triangulation with the old lake survey stations, except at Ogdensburg, where a base line for triangulation was measured by wooden rods compared with the standard bar of the base apparatus.

The base lines and the distance across the river were carefully computed, and new tables constructed.

The following table shows the method followed in the final computation of the work. It gives part of the work of one day on the St. Clair river:

Table of computation of part of one day's work on the St. Clair river.

Date.	Number of float.	Angle at upper station.	Angle at lower station.	Upper section distant from west shore.	Lower section distant from west shore.	Distance passed over by floats.	Time.	Velocity.	Depth of float.	Direction of wind.	Velocity of wind.	Velocity at right angle with stream.	Velocity reduced to direction of stream.	Water gauge.
		° ′	° ′	*Feet.*	*Feet.*	*Feet.*	*M. S.*	*Feet.*	*Ft.*		*M.*			*Ft.*
June 28, 1867...	1	41 38	42 41	514	532	685	2 33	4.477	5	N. E.	9.12	8.5	3.0	1.81
Do.....	2	41 36	42 23	508	532	685	2 34	4.448	10	.....	.....	.....	.....	....
Do.....	3	41 14	42 17	506	520	685	2 26	4.692	10	.....	.....	.....	.....	....
Do.....	4	44 53	43 53	539	605	686	2 38	4.342	15	.....	.....	.....	.....	....
Do.....	5	40 57	42 21	507	513	685	2 47	4.102	20	.....	.....	.....	.....	....
Do.....	6	41 25	42 32	511	525	685	2 30	4.567	25	.....	.....	.....	.....	....
Do.....	7	41 35	43 05	523	529	685	2 42	4.229	25	.....	.....	.....	.....	....
Do.....	8	40 10	(411?)51	497	498	685	2 41	4.255	25	.....	.....	.....	.....	....
Do.....	9	42 45	43 41	535	555	685	2 39	4.308	25	N. E.	8.00	7.5	2.7	1.80
Do.....	10	40 18	42 17	506	502	685	2 47	4.102	30	.....	.....	.....	.....	....
Do.....	11	42 30	42 46	516	549	686	2 57	3.873	30	.....	.....	.....	.....	....
Do.....	12	40 42	41 50	497	522	686	2 46.5	4.115	35	.....	.....	.....	.....	....
Do.....	14	40 47	42 02	501	533	686	2 59	3.830	40	.....	.....	.....	.....	....
Do.....	15	52 16	53 35	793	817	688	2 34	4.465	5	.....	.....	.....	.....	....
Do.....	16	52 49	53 56	804	839	688	2 36.5	4.396	10	.....	.....	.....	.....	....
Do.....	17	52 32	53 05	776	828	689	2 39	4.331	10	.....	.....	.....	.....	....
Do.....	18	53 40	54 40	828	867	688	2 40	4.299	15	.....	.....	.....	.....	....
Do.....	19	52 31	53 55	804	827	687	2 39.5	4.309	20	.....	.....	.....	.....	....
Do.....	20	53 02	54 21	817	836	687	2 42.5	4.204	25	.....	.....	.....	.....	....
Do.....	21	52 10	54 04	807	815	687	2 37	4.376	25	.....	.....	.....	.....	....
Do.....	22	52 24	53 56	804	829	687	2 43	4.215	25	.....	.....	.....	.....	....
Do.....	23	50 54	53 04	776	764	687	2 47	4.114	25	.....	.....	.....	.....	....
Do.....	24	51 48	53 39	796	802	687	2 43.5	4.204	30	N. E.	4.30	3.7	1.5	1.79
Do.....	25	51 20	53 38	795	777	687	2 53	3.972	30	.....	.....	.....	.....	....
Do.....	26	51 58	54 01	806	808	687	2 52	3.995	35	.....	.....	.....	.....	....
Do.....	27	51 14	53 37	795	783	687	2 49.5	4.045	40	.....	.....	.....	.....	....
Do.....	29	66 21	69 00	1,564	1,546	691	5 41	2.027	5	.....	.....	.....	.....	....
Do.....	30	66 33	69 25	1,599	1,562	692	6 04.5	1.901	5	N.	6.40	6.0	2.0	1.78
Do.....	31	66 40	69 15	1,585	1,572	691	5 56	1.942	10	.....	.....	.....	.....	....
Do.....	32	66 05	69 09	1,577	1,523	693	5 40	2.039	10	.....	.....	.....	.....	....
Do.....	33	66 17	69 21	1,593	1,529	694	6 32.5	1.771	10	.....	.....	.....	.....	....
Do.....	34	66 33	69 22	1,595	1,562	692	7 03.5	1.631	10	.....	.....	.....	.....	....
Do.....	35	66 30	.....	.....	1,558	691	7 22	1.563	15	.....	.....	.....	.....	....
Do.....	36	66 05	.....	.....	1,523	691	5 39.5	2.035	15	.....	.....	.....	.....	....

In the *first* column is the date; next, the number of the float from the commencement of the day's work; *third* and *fourth*, the angle at each station between the float and the base line; *fifth* and *sixth*, the distance of the float from each station, taken from the table spoken of above, the argument being the angles given in the preceding columns; *seventh*, the distance traveled by the float. (This is a variable quantity, because, first, the distance between the flags was not exactly the same as the length of the base line; and also because the path of the float was rarely perpendicular to the cross lines. The first difference was found by a simple proportion, and the second by a table giving the increase of distance for every foot of departure, the difference of the distances from the stations in the fifth and sixth columns showing the amount of departure.) *Eighth*, the time of passage of the float; *ninth*, the velocity of the float per second, which was taken from a computed table of which the arguments were, the time of passage, and the distance traveled; *tenth*, the depth of the float beneath the surface; *eleventh* and *twelfth*, the direction and velocity of the wind, the velocity being measured by a Robinson's anemometer made by James Green; *thirteenth* and *fourteenth*, the resultant direction and velocity of the wind parallel to the current of the river; and *fifteenth*, the readings of the water gauge.

A system of planes parallel to the base line, 200 feet apart, were conceived to pass, dividing the river into divisions according to the method

opted by General Humphreys, the divisions nearest the banks being bdivided on account of the difference of the velocities in different rts of these divisions.

An inspection of the fifth and sixth columns of the preceding table ll show in what division each of the velocities will fall.

The velocities were tabulated for each day, and each five feet of depth, d the means for each depth are given in the following tables:

Tables of mean velocities in each division and at each five feet of depth in feet per second.

STE. MARIE RIVER.

Depths.	1.	2.	3.	4.	5.	6.	7.	8.
	0.392	0.600	0.795	0.892	0.976	1.434	1.872	1.872
	.....	0.505	0.802	0.889	0.900	1.308	1.782	1.914
	.....	.....	0.864	0.847	0.761	1.451	1.811	1.921
	.....	.....	0.696	0.867	.....	1.288	1.735	1.845
	.....	.....	.....	.....	.....	.....	1.577	1.749
	.....	.....	.....	.....	.....	.....	1.730	1.734
	.....	.....	.....	.....	.....	.....	.....	.....
	0.392	0.552	0.789	0.874	0.879	1.345	1.751	1.839

Depths.	9.	10.	11.	12.	13.	14.	15.	16.
	1.723	1.458	1.376	1.194	0.789	0.538	0.292	0.205
	1.653	1.432	1.230	1.199	0.828	0.567	.....	.....
	1.668	1.398	1.090	1.141	0.761	0.514	.....	.....
	1.618	1.341	1.038	1.010	.....	.....	.....	.....
	1.475	1.119	1.270	0.898	.....	.....	.....	.....
	1.552	.....	.....	.....	.....	.....	.....	.....
	1.463	.....	.....	.....	.....	.....	.....	.....
	1.593	1.350	1.199	1.088	0.793	0.540	0.292	0.205

ST. CLAIR RIVER.

Depths.	1.	2.	3.	4.	5.	6.	7.	8.
	2.391	4.149	4.468	4.329	4.200	3.741	3.346	2.532
	2.612	4.076	4.546	4.432	4.274	3.552	3.277	2.396
	2.564	4.083	4.313	4.427	4.092	3.609	3.385	2.288
	2.687	3.801	4.345	4.176	3.870	3.638	3.131	2.101
	2.945	4.083	4.376	4.260	4.074	3.690	3.171	2.052
	.....	3.693	4.092	3.878	4.044	3.668	.....	.....
	.....	3.694	3.929	3.918	4.042	3.282	.....	.....
	.....	.....	3.912	3.846	3.880	3.432	.....	.....
	.....	.....	.....	3.775	3.972	.....	.....	.....
	2.633	3.939	4.248	4.115	4.049	3.577	3.262	2.274

NIAGARA RIVER.

epths.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
	1.345	1.633	3.106	3.282	3.267	3.273	3.074	2.618	2.058	1.715	1.459
	.....	1.763	2.625	3.148	3.299	3.092	3.058	2.952	2.153	1.798	1.374
	.....	.....	.....	3.240	3.327	3.370	3.142	2.720	2.134	1.845	.....
	1.018	1.363	2.789	3.355	3.287	3.242	3.011	2.826	2.029	1.611	.....
	.....	1.651	2.278	3.172	3.266	3.140	3.001	2.812	2.232	1.882	1.200
	0.889	1.687	2.383	3.145	3.197	3.189	3.056	2.787	2.103	1.631	.....
	.....	1.290	2.729	3.101	3.150	3.164	3.004	2.567	2.064	.....	.....
	.....	.....	2.724	3.179	3.344	2.900	2.670	2.518	.....	.....	.....
	.....	.....	2.470	2.927	2.978	2.863	2.717	.....	.....	.....	.....
	.....	.....	2.512	3.041	3.194	2.477	.....	.....	.....	.....	.....
	.....	.....	2.137	.....	.....	.....	.....	.....	.....	.....	.....
	0.813	1.431	2.569	3.159	3.231	3.071	2.970	2.725	2.110	1.747	1.011

Table of mean velocities in each division, &c.—Continued.

ST. LAWRENCE RIVER.

Number.	1.	2.	3.	4.	5.	6.	7.	8.	9.
5	0.5250	0.9794	1.1445	1.3600	1.4627	1.4405	1.3406	1.3462	1.3214
10	0.5380	0.9502	1.1297	1.3500	1.4532	1.3880	1.3534	1.3162	1.3254
15	.....	0.9280	1.0895	1.2897	1.4245	1.3465	1.2918	1.2642	1.2822
20	.....	0.8998	1.1000	1.2595	1.3650	1.3500	1.2760	1.2440	1.2700
25	.....	0.8720	1.0608	1.2196	1.4102	1.3202	1.3066	1.2462	1.2386
30	.....	0.8792	1.0432	1.2262	1.3435	1.2880	1.2712	1.2362	1.2158
35	.....	0.8460	0.9896	1.2052	1.3182	1.2465	1.2360	1.1975	1.1620
40	.....	0.8165	0.9984	1.1716	1.2900	1.2480	1.1908	1.1722	1.1588
45	.....	.....	0.9429	1.0884	1.2662	1.2002	1.2144	1.1195	1.1250
50	.....	.....	0.9882	1.0630	1.2577	1.1852	1.1610	1.0600	1.1058
55	.....	.....	.....	1.0413	1.1060	1.1470	1.1590	.....	.....
Means	0.5315	0.8964	1.4497	1.2068	1.3361	1.2773	1.2553	1.2192	1.2205

Number.	10.	11.	12.	13.	14.	15.	16.	17.	18.
5	1.2342	1.1950	1.1830	1.0505	0.9785	0.8760	0.6065	0.3675	0.2870
10	1.2366	1.1660	1.1240	0.9772	0.9272	0.8560	0.5016	0.4660	1.4670
15	1.2390	1.1724	1.0688	1.0002	0.9228	0.7660	1.4580	0.3190	.....
20	1.2356	1.1282	1.0345	0.9720	0.8708	0.7163	.....	.....	.....
25	1.2104	1.0806	0.9625	0.9287	0.8223	.....	.....	.....	.....
30	1.1716	1.0672	0.9165	0.8366	.....	.....	.....	.....	.....
35	1.1400	1.0456	0.8720	.....	.....	.....	.....	.....	.....
40	1.1332	1.0632	.....	.....	.....	.....	.....	.....	.....
45	1.0540	.....	.....	.....	.....	.....	.....	.....	.....
50	.....	.....	.....	.....	.....	.....	.....	.....	.....
55	.....	.....	.....	.....	.....	.....	.....	.....	.....
Means	1.1838	1.1148	1.0202	0.9608	0.9043	0.8036	0.5220	0.3912	0.3870

The area of the cross-section of each end of the several divisions was then found from the soundings and the mean middle area taken. The mean areas for the lines on which the soundings were taken are:

Mean areas of each division.

ST. MARY'S RIVER.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
950	3350	5170	5170	5130	5237	6493	8107	7903	6010	5440	5277	4979	4250	3238	1867

ST. CLAIR RIVER.

1.	2.	3.	4.	5.	6.	7.	8.
8682	7938	8833	10335	10206	9656	5247	7243

NIAGARA RIVER.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
7301	13880	11362	10474	10088	9774	9652	8594	7568	2694

ST. LAWRENCE RIVER.

1.	2.	3.	4.	5.	6.	7.	8.	9.
5064	19000	22050	24600	25700	24900	23610	22150	21950

Mean areas of each division—Continued.

ST. LAWRENCE RIVER.

10.	11.	12.	13.	14.	15.	16.	17.	18.
20900	17850	14450	12640	11320	10120	8400	5500	1025

These mean areas were corrected for each day, by the amount of the rise or fall of the water, as shown by the gauge.

The areas at each end of the divisions being somewhat different, it was thought better to use the mean area, particularly as the velocity obtained by the floats was that of the whole distance between the cross-sections, and was therefore more properly used as the velocity past the middle than past either end of the divisions.

The discharge in each division was obtained by multiplying the mean velocity for each day by the mean area, plus or minus the correction for the height of the water for the day. These amounts are given in the columns in the following table, and the means show the mean discharge in each division:

Tables of discharge in each division for each day observed, in cubic feet per second.

STE. MARIE RIVER.

Date.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
July 3					4,301			15,265						2,943		
5	432								12,151	9,392						
6										9,495		5,601				
8		2,168	5,062			5,588		15,263								
9		1,871		4,303	4,062		11,528		12,130		6,390					
11			4,996	4,576	5,570			14,747					5,672	2,834		
12					5,258							6,182		3,382	1,313	
13									10,573							
16				5,294		6,997		15,184								
17									12,027	8,276	5,505					
18												5,581	3,770	1,479		
19		1,923	4,028	4,188	3,321	6,706		14,744	10,816		6,116	3,758				
20												5,441	3,315	1,734	684	
22		2,310	4,184	4,137	4,624	9,074	11,325	15,500	11,760	8,377						331
23							9,735	14,059	12,592	7,850	7,570	6,958	5,044	2,143	1,186	
24		2,303	4,203	4,915	4,723	8,829	12,088	15,453								
25									13,119	8,770	7,237	6,984	3,694	2,006	852	524
26			4,121	3,198	3,986	6,711	11,686	13,773								
27	324	1,907	3,599													
29				4,876	5,530	9,076		17,276								
30						5,577			12,711	7,488	6,781	6,351	3,482			
Aug. 2						8,431		15,776								
3									11,807							
5			3,626	4,806	4,366	6,855	11,203	15,391	11,943	8,096	6,735	6,159				
Mean	378	2,080	4,227	4,477	4,574	7,404	11,428	15,203	11,966	8,468	6,619	5,891	4,163	2,360	1,009	436

Sum: 90,783 cubic feet.

Table of discharge in each division for each day observed, in cubic feet per second.

ST. CLAIR RIVER.

Date.	1.		2.	3.	4.	5.	6.	7.	8.	
June 20	2,756	9,815	27,038		46,185 49,821	41,517		17,610		

9					44,580	42,517	33,944	21,639	11,151	2,554
11			29,370	36,122	43,600	41,760				
13	2,372		27,798				36,608	18,135	10,166	2,795
15			30,279	38,341						
16				37,580	45,424					
17								21,352	12,053	3,125
18	2,700		31,533	38,266	42,690	43,133				
19				36,790	41,914					
Mean	2,747	9,524	30,884	37,708	43,615	41,868	34,596	19,494	10,651	2,642

Sum = 233,726 cubic feet.

Table of discharge in each division for each day observed, in cubic feet per second.

NIAGARA RIVER.

Date.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Aug. 20				40,573	35,794						
22		6,416			36,575	32,684					
23							30,721	26,652			
24				39,944	34,592	31,914	29,303	28,354			
26					35,712	36,366	28,865	27,316	18,710	14,439	
27									20,191	16,000	4,108
Sept. 2	2,882	7,840									
3								29,121		16,031	
4		7,822	37,723	37,368	34,354	33,129	30,512		19,215		3,197
5						31,291	29,987	28,577	19,800		
7		8,426	36,487	35,824	34,515						
11			39,863	36,812	34,847	33,991	30,798	27,479			
12									17,726		
13				37,635						12,923	2,602
14			36,755	34,948					17,034		
16							29,814	27,065	17,890	13,313	
17			40,507				31,181	26,268			
18								26,199	15,548		
19	1,879	7,346	22,030						19,004		

Table of discharge in each division for each day observed, in cubic feet per second.

NIAGARA RIVER—Continued.

Date.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Sept. 20											2,696
21				36,520	32,905	31,718	28,887			12,816	
23	2,139	7,413		34,728		27,764					
24			39,514	33,811	34,856						
25								24,103			
Mean	2,300	7,544	36,911	36,716	34,906	32,357	30,008	27,113	17,234	14,254	3,151

Sum: 242,494 cubic feet.

Table of discharge in each division for each day observed, in cubic feet per second.

ST. LAWRENCE RIVER.

Date.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Aug. 3		16,720	22,081															
5									30,070									
7				32,416	34,817	34,145	31,914	30,054	29,116									
8	2,812	20,070	24,240	28,545														
9					35,184	34,270	34,270	32,252										
12			26,340	29,968														
17		16,737					31,167	27,800	25,382									
21										26,886	22,066	15,780	12,813	10,696		5,301	2,424	
22										23,792	19,902				9,541	2,857	1,129	
23										27,158	19,953	15,532	11,172	9,963	7,435			
24										23,803	20,120	14,250	11,714	9,669	8,076	4,796	2,251	
Sept. 4													13,244	10,853	7,677	4,414	2,260	289
5										23,174	17,607	15,011						
6	15,700	25,093																
7		12,014	25,513	29,935	29,024													
11						27,525	27,071	29,375										
14						25,667	24,020	22,926										
16			30,180	37,340	31,030													
17	22,025	17,045	25,228															
	2,506	17,254	22,166	29,324	34,319	32,117	30,250	27,236	27,374	24,962	19,936	15,143	12,236	10,300	8,189	4,342	2,017	289

Sum: 319,043 cubic feet.

ıave not attempted to fill the blanks in the tables by interpolation, he observations are as yet too limited to discuss the form of the ːity curves.

ıe velocity in a vertical plane seems to be different for each of the ɜ of observation, and in none is the data sufficient to clear the curve eat irregularities.

ıe velocity curves in the horizontal planes are given in Figs. 9–11, which it will be seen that these curves approximate more nearly to lipse than to a parabola.

ıe latter was the form to which General Humphreys reduced the es on the Mississippi.

ıt it will be better to defer all discussion of this branch of the sub- until we have more extended observations.

ıe boundary line of the water-shed of the lakes is shown by the dot- ine on the accompanying map.

ıe water-shed was measured to the headwaters of all streams empty- nto the lakes, as shown by the land-survey maps.

the following table is given, in square miles, the water-shed and ıce of the open water for the several lakes and connecting rivers:

	Lake surface.	Water-shed.
Superior	38,875	51,630
ıarie's river	150	830
Michigan	20,838	37,678
Huron	29,383	31,712
ıir river	25	3,863
St. Clair	427	3,425
it river	25	1,225
Erie	9,522	21,371
lakes south of Lake Erie	1,350	.....
ra river	15	300
Ontario	7,181	21,587
wrence river	40	1,950
lakes north of Lake Ontario	800	.....

ıe rain-fall at various places on or near the water-shed of the lakes ven below. This table is compiled from the Smithsonian, army, nto, and other meteorological reports, and from the records in this ɔ. These amounts are also marked upon the map.

Table of rain-fall in the lake region.

ken.	Places of observation.	No. of years' observations.	Mean yearly rain-fall.	Mean rain-fall for the lakes.	Mean daily rain-fall.
			Inches.	*Inches.*	*Inches.*
or ...	Superior, Wisconsin	8	26.0	28.38	0.0774
	Ontonagon, Michigan	8	26.2		
	Marquette, Michigan	8	29.1		
	Sault Ste. Marie, Michigan	17	30.8		
an ...	Fort Howard, Wisconsin	8	34.6	30.63	0.0843
	Appleton, Wisconsin	3	31.8		
	Fort Winnebago, Wisconsin	9	27.5		
	Milwaukee, Wisconsin	21	30.3		
	Janesville, Illinois	5	32.6		
	Battle Creek, Michigan	3	33.5		
.....	Mackinac, Michigan	12	23.7	27.94	0.0753
	Thunder Bay Island, Michigan	7	33.2		
	Tawas, Michigan	8	22.1		
	Fort Gratiot, Michigan	11	32.6		

Table of rain-fall in the lake region—Continued.

Lakes.	Places of observation.	No. of years' observations.	Mean yearly rain-fall.	Mean rain-fall for the lakes.	Mean daily rain fall.
			Inches	*Inches.*	*Inches.*
Erie	Detroit, Michigan	9	29.2	32.84	0.0899
	Monroe, Michigan	8	30.7		
	Oberlin, Ohio	3	33.3		
	Cleveland, Ohio	9	37.9		
	Hudson, Ohio	9	33.6		
	Buffalo, New York	9	32.6		
Ontario	Fort Niagara, New York	8	26.8	31.85	0.0872
	Toronto, Ontario. (Canada)	8	36.4		
	Rochester, New York	4	35.6		
	Penn Yan, New York	6	28.7		
	Charlotte, New York	8	29.8		
	Sackett's Harbor, New York	8	35.8		

It is to be regretted that these observations are not more extended, especially that we have no records for the country to the northward of the lakes.

As the rain-fall generally lessens as we go north, the amounts given in the table are, therefore, probably too great.

The following table gives the total amount of rain-fall on the water-shed and lake surface, and its ratio with the discharge:

Section.	Water-shed and lake surface.	Daily rain-fall.	Rain-fall on water-shed and lake surface per day.	Rain-fall per second.	Rain-fall per second in each section.	Discharge per second in each section.	Ratio of rain-fall and discharge.
	Sq. miles.	*Inches.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	
Lake Superior	90,505	0.0774	16,274,220,824	188,359	188,359	90,783	0.48
Lakes Michigan and Huron	121,941	0.0798	22,606,807,240	261,653	450,012	233,786	0.52
Lake Erie	40,298	0.0899	8,416,676,470	97,415	547,427	242,294	0.44
Lake Ontario	31,558	0.0872	6,393,116,177	73,994	621,421	325,839	0.52

The daily amount of rain-fall was used for convenience in computation, and in the fifth column the total amount of rain received on the water-shed and surface of the several lakes is given for each second.

For comparison with the discharge of each section in the sixth column these amounts are added together in sequence. The discharge given in the seventh column is corrected for the difference of the height of the water during the times of gauging.

This is obtained from the table previously given of the readings of the water-gauge, the difference in the mean height at Niagara and Ogdensburg during the time of gauging the Ste. Marie's and St. Clair, and during the time of gauging the former places, being multiplied by the proper cross-section and the product added to the amounts obtained for those places.

The last column gives the ratio of the discharge to the drainage. This, it will be noticed, is the same—52 per cent. for Lakes Huron, Michigan, and Ontario—while for the others it is much smaller.

In order to ascertain why this difference arises, it is necessary to find what portion of the rain-fall is lost on land, and what by evaporation from the lake surface.

The question of evaporation can generally be omitted in computing the discharge of large rivers, for their surface is so small in proportion to the volume of water passing through them that this loss is practically inappreciable.

But the lakes are widely extended and joined by small rivers; and this great expanse of water, moving with hardly a perceptible current, is exposed to the direct influence of the sun, and in calm weather the loss of water from this cause is very great.

In my report on the meteorology of the lakes I have given the amount of evaporation at various places, and have also shown how a close approximation to its value can be obtained when the rain-fall and mean temperature are known.

In the following table the amount of evaporation from the surface of the several lakes is given for each day and each second, and the latter is subtracted from the amount of rain-fall given in the previous table:

Section.	Lake surface.	Daily evaporation.	Daily evaporation from lake surface.	Evaporation per second.	Rain-fall per second, less evaporation in each section.	Discharge per second in each section.	Ratio.
	Sq. miles.	*Inches.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	
Lake Superior	38, 875	0. 0436	3, 946, 785, 455	45, 680	142, 679	90, 783	0. 64
Lakes Michigan and Huron	51, 721	0. 0637	7, 654, 078, 571	88, 589	315, 743	233, 726	0. 74
Lake Erie	10, 114	0. 0672	1, 579, 988, 000	18, 275	394, 883	242, 894	0. 61
Lake Ontario	8, 021	0. 0631	1, 175, 839, 788	13, 609	455, 268	325, 839	0. 72

A more difficult and uncertain problem is, how much of the rain-fall on the land reaches the lakes.

The amount of water required for vegetable growth is very large. Saussure states that 10,000 sunflowers can be grown to an acre, and that each plant exhales 230 pounds of water in four months. Cabbages throw out about the same amount, and a wheat plant loses 113,527 grains of water in 172 days.

The water thus required for sunflowers would amount to over ten inches in depth for the four months, and the wheat would need nearly the same amount.

Mr. I. A. Lapham. LL.D., of Milwaukee, in his report to the legislature of Wisconsin on the destruction of forest trees, estimates from the amount of earthy matter contained in natural water that "a rain-fall of nine inches would be required to supply the water which must necessarily be consumed to produce the mineral matter annually formed or deposited in the tissues of plants." Thus it will be seen that fully one fourth of the water which falls in this latitude is required for the growth of the ordinary vegetation.

In the States of Michigan and Wisconsin are hundreds of small lakes or ponds which drain a large extent of country, and many of which have no visible outlet. In these, therefore, the evaporation is nearly or quite equal to the amount of water drained into them, and will thus decrease the amount received into the lakes from the water-shed.

Again, a certain amount must be evaporated from the surface of the ground, and from the rivers and streams. At least one-fourth more of the rain-fall must be lost in this manner. General Humphreys gives in his report a table of the ratio of rain-fall and discharge in various localities. Part of these are of the Mississippi river, which, in its lower reaches, runs through low and swampy land, and part are of the English

moor and fen lands. Omitting these as not comparable with the country surrounding most of the lakes, there remain 14 places which give a mean ratio of 55 per cent.; that is, the discharge is equal to 55 per cent. of the rain-fall, which would be about the same as is estimated above. The discharge of the Thames river, England, is estimated at only one-third of the rain-fall, which is also the amount generally accepted by hydraulic engineers.

In the following table I have taken one-half of the rain-fall on the water-shed and subtracted it from the amount of drainage given in the last table:

Section.	Water-shed.	Half of the daily rain-fall.	Half of the daily rain-fall on the water-shed.	Half of the rain-fall per second on the water-shed.	Drainage in each section per second.	Discharge per second in each section.	Ratio drainage and discharge.
	Sq. miles.	*Inches.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	
Lake Superior	51,630	0.0387	4,641,943,011	53,726	88,953	90,783	1.02
Lakes Michigan and Huron	70,220	0.0399	6,509,100,000	75,337	186,680	233,726	1.25
Lake Erie	30,184	0.0450	3,152,751,450	36,490	229,330	242,894	1.06
Lake Ontario	23,537	0.0436	2,384,098,352	27,594	262,121	325,839	1.24

Here it will be seen that the ratio exceeds unity; that is, that the amounts now taken from the water received are too great. I have, therefore, in the following table, worked back, and found the percentage of rain required to be subtracted to make the drainage and discharge equal.

Lakes.	Per cent. of rain-fall in each section.	Rain-fall per second in each section.	Drainage in each section, per second.	Discharge per second in each section.	Ratio.
		Cubic feet.	*Cubic feet.*	*Cubic feet.*	
Lake Superior	0.48	51,577	91,102	90,783	1.00
Lakes Michigan and Huron	0.32	82,410	233,333	233,726	1.00
Lake Erie	0.45	151,125	243,758	242,894	1.00
Lake Ontario	0.33	130,202	345,066	325,839	1.00

Here we see that in the first section 52 per cent. of the rain-fall is discharged, and in the third section 55 per cent., while in the second and fourth sections 68 and 67 per cent., respectively, is required. This would seem to show that there must be some source of supply beside the rain for Lakes Michigan, Huron, and Ontario. That there are subterranean rivers near the lakes is shown by the salt wells of St. Clair and Saginaw, and particularly by the artesian well at Chicago, where the water rises 125 feet above the surface of Lake Michigan.

The curves of the height of the water through a series of years show that Lake Ontario is apparently affected in some manner different from Lake Erie, for the water will at times be high in the former when it is comparatively low in the latter. Lake Michigan shows the same differences, but in a less degree; but Lake Erie intervenes between the second and fourth sections, and it does not seem to be affected in the same manner. In fact the difference between the amount of water discharged

at Niagara and St. Clair is much less than the amount of rain received on the water-shed, less the amount of evaporation on Lake Erie.

	Cubic feet per second.
Discharge at St. Clair	233,726
Discharge at Niagara	242,894
Difference	9,168

Amount of rain-fall on the water-shed of Lake Erie, less the evaporation of the lake, 161,801 cubic feet per second, or about six hundredths per cent.

From this it would seem, if these estimates are correct, that there must be an escape of water from Lake Erie into Lake Ontario otherwise than by Niagara river.

But all such calculations are rather premature, for the more extended series of observations to be made the coming season may change the amount of discharge found for one of these places.

In the summer of 1841 Messrs. Z. Allen and E. R. Blackwell (*vide* Silliman's Journal No. 46, first series, p. 67, sequel) made a few observations on the current of Niagara river at Black Rock harbor above the falls by means of surface floats. They computed the discharge by means of Eytelwein's formula, and found it to be 374,000 cubic feet. There being apparently some mistake, I had the discharge recomputed from their notes, and also using the soundings given by the lake survey on the Buffalo harbor chart, which were in some cases a little smaller than those they give.

Their method of observation was the sounding of three cross-section lines, one-eighth of a mile apart, and the velocity of surface floats was found in five places between the first and second and the second and third lines; thus, as they say, giving the surface velocity of the current in 10 places but in reality only in five.

In our computations the river was divided into divisions between the places where the velocities were observed, and the velocity of the current between the last velocity given on each side and the shore was found by plotting the several velocities and drawing a curve which would come the nearest to them and the ends of the cross-section. (This appeared to be an ellipse.)

Then taking on this curve a point half way between the last velocity on each side and the shore, I called that the velocity of the first and last divisions.

The computations are given in the following table.

Table of discharge at Black Rock harbor, Niagara river, 1841.

Division.	Velocity in miles per hour.	Velocity in feet per second.	Of mean cross-sect'n.	Discharge per second.
	Miles.	*Feet.*	*Square feet.*	*Cubic feet.*
1	4.403	6.455	3,950	25,497
2	6.217	9.118	4,905	44,724
3	6.901	10.121	4,611	46,668
4	7.090	10.399	8.455	87,923
5	6.368	9.340	4,008	37,434
6	4.633	6.795	3,978	27,031
Total				269,277

Taking 10-elevenths of the above, according to the formula of Eytelwein's, we have for the total discharge 244,797; or, corrected for the difference of the level of the water in 1841 and 1867, 245,797 cubic feet. This it will be seen is only about 2,000 cubic feet more than the amount given in the foregoing tables.

In 1856 the parties surveying the St. Clair Flats made a few observations on the velocity of the current in three of the passes, the north, (including both mouths,) the middle, and the south. The discharge as computed from these observations amounts to 212,325 cubic feet.

There are two other passes, the Junitogen and the Sincardy, as they are called in the sailor's jargon; but they are both small and but little water passes through them.

These are, I believe, the only attempts ever made to ascertain the amount of water flowing through the lakes.

As geologists think they have discovered an old channel by which the water from Lake Erie was drained into Lake Ontario before the present falls existed, it is rather a curious problem to ascertain how long the lake would be filling up to its present level, supposing it had been drained and then the outlet blocked up.

The mean depth of the lake is about 50 feet; this multiplied into the surface given in a previous table would give its cubic contents, 1,174,847,567,578 cubic feet. This divided by the discharge of St. Clair shows that nearly 58 days and two hours would be required to fill the lake.

The daily amount of water at present brought by the Croton mains for the supply of the city of New York is 90,000,000 gallons; this would be supplied in less than 37 seconds by discharge of the lakes at Ogdensburg.

Very respectfully, your obedient servant,

D. FARRAND HENRY,
Assistant Lake Survey.

Brevet Brig. Gen. W. T. RAYNOLDS,
In charge of Lake Survey.

APPENDIX W *c*.

REPORT ON THE SURVEY OF THE NORTHERN AND NORTHWESTERN LAKES.

SIR: I have the honor to submit the following report on the meteorology of the lakes for the past year.

I have not been able to give as much attention this winter to this department as it really needs, on account of my time being taken up by the reduction of the observations on the outflow of the lakes.

Last summer I visited and inspected most of the stations, and changed some of the instruments. I also set up a self-registering tide-gauge at Charlotte, on Lake Ontario.

I found almost everything in good order, and the observers generally doing very well.

New instruments will be needed by some of them this year, and self-registering water-gauges should be established on the two lakes (Lake Huron and Lake Erie) now without them.

I give, in accompanying tables, the general reductions of the meteorological observations for the year 1867, arranged and computed as usual.

Bvt. Brig. Gen. W. F. RAYNOLDS,
In charge Lake Survey.

Maximum, minimum, and mean of the barometrical pressure, reduced to 32° Fahr. + 25 inches.

Places.	Number of years.	January.			February.			March.			April.			May.			June.		
		Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
Superior City	8	2.371	0.547	1.345	1.916	0.513	1.345	2.018	0.567	1.317	1.878	0.245	1.279	1.762	0.259	1.259	1.753	0.685	1.261
Ontonagon	8	2.430	0.359	1.311	1.946	0.444	1.342	1.929	0.502	1.324	1.859	0.311	1.305	1.897	0.214	1.270	1.789	0.412	1.278
Marquette	8	2.421	0.548	1.251	1.921	0.444	1.264	1.957	0.495	1.272	1.848	0.382	1.267	1.750	0.284	1.233	1.734	0.619	1.237
Milwaukee	8	2.503	0.665	1.404	1.921	0.529	1.374	1.888	0.655	1.341	1.999	0.511	1.326	1.753	0.447	1.293	1.730	0.770	1.336
Grand Haven	4	1.971	0.620	1.379	1.880	0.352	1.357	1.827	0.499	1.381	1.867	0.568	1.336	1.717	0.567	1.310	1.694	0.695	1.347
Thunder Bay Island	7	1.979	0.563	1.352	1.992	0.551	1.344	1.887	0.050	1.279	1.984	0.481	1.351	1.842	0 530	1.323	1.824	0.732	1.349
Tawas	9	2.611	0.635	1.385	2.017	0.573	1.354	1.899	0.059	1.310	1.981	0.556	1.341	1.849	0.545	1.303	1.900	0.627	1.331
Detroit	9	2.630	0.656	1.406	2.073	0.566	1.387	1.872	0.469	1.329	1.958	0.562	1.325	1.752	0.658	1.299	1.782	0.680	1.301
Monroe	8	2.641	0.676	1.428	2.039	0.548	1.413	1.947	0.626	1.361	1.990	0.648	1.357	1.759	0.600	1.310	1.747	0.704	1.359
Cleveland	8	2.509	0.731	1.357	2.034	0.534	1.348	1.753	0.535	1.283	1.894	0.547	1.283	1.820	0.539	1.240	1.703	0.628	1.302
Buffalo	8	2.526	0.606	1.375	2.146	0.596	1.379	1.886	0.570	1.316	2.007	0.536	1.345	1.754	0.390	1.280	1.832	0.679	1.326
Fort Niagara	7	2.957	0.958	1.765	2.413	0.023	1.775	2.400	0.828	1.719	2.322	0.980	1.739	2.266	0.936	1.655	2.224	1.104	1.712
Charlotte	8	2.989	0.906	1.734	2.582	0.930	1.738	2.311	0.867	1.666	2.355	0.795	1.702	2.182	0.679	1.619	2.183	0.970	1.661
Sackett's Harbor	8	2.949	0.867	1.717	2.555	0.941	1.708	2.290	0.859	1.672	2.357	0.767	1.700	2.191	0.810	1.611	2.186	1.088	1.650

	Number of years.	July.			August.			September.			October.			November.			December.		
		Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
Superior City	8	1.765	0.692	1.274	1.650	0.810	1.307	1.839	0.674	1.308	2.026	0.388	1.314	2.004	0.393	1.272	2.019	0.893	1.335
Ontonagon	8	1.747	0.648	1.284	1.785	0.772	1.316	1.840	0.667	1.326	1.963	0.314	1.331	2.054	0.385	1.280	2.017	0.320	1.301
Marquette	9	1.676	0.700	1.264	1.663	0.758	1.295	1.861	0.703	1.298	1.852	0.434	1.292	2.157	0.355	1.236	1.975	0.285	1.272
Milwaukee	9	1.696	0.902	1.352	1.702	0.971	1.365	1.828	0.803	1.377	1.967	0.658	1.376	2.040	0.549	1.329	2.032	0.552	1.385
Grand Haven	4	1.673	0.892	1.341	1.689	1.033	1.386	1.864	0.950	1.421	1.842	0.665	1.394	1.974	0.588	1.325	2.248	0.723	1.442
Thunder Bay Island	7	1.806	0.782	1.351	1.690	0.809	1.372	1.903	0.753	1.404	1.950	0.658	1.362	2.129	0.421	1.326	2.069	0.519	1.383
Tawas	9	1.815	0.807	1.346	1.731	0.860	1.365	1.892	0.792	1.407	1.986	0.648	1.389	2.132	0.441	1.335	2.109	0.472	1.373
Detroit	8	1.692	0.933	1.359	1.786	0.946	1.386	1.869	0.983	1.429	1.979	0.708	1.404	2.099	0.637	1.359	2.039	0.636	1.411
Monroe	9	1.854	0.983	1.274	1.720	0.962	1.393	1.891	1.012	1.447	1.928	0.757	1.470	2.059	0.670	1.391	2.101	0.661	1.437
Cleveland	9	1.776	0.907	1.318	1.699	0.875	1.329	1.797	0.903	1.374	1.843	0.682	1.354	2.022	0.512	1.316	1.993	0.528	1.370
Buffalo	9	1.875	0.990	1.347	1.822	0.888	1.365	1.862	0.822	1.417	1.902	0.578	1.384	2.145	0.429	1.345	2.117	0.494	1.392
Fort Niagara	8	2.119	1.306	1.708	2.183	1.248	1.733	2.297	1.118	1.792	2.355	0.980	1.770	2.617	0.876	1.725	2.521	0.965	1.774
Charlotte	9	2.202	1.248	1.664	2.133	1.175	1.690	2.207	1.147	1.754	2.338	0.767	1.723	2.553	0.947	1.684	2.501	0.892	1.747
Sackett's Harbor	9	2.207	1.203	1.662	2.105	1.223	1.683	2.266	0.888	1.749	2.326	0.951	1.714	2.556	0.995	1.670	2.479	0.887	1.747

Maximum, minimum, and mean of the barometrical pressure for seasons and years, reduced to 32° Fahr. + 28 inches.

	Number of years.	Spring.			Summer.			Autumn.			Winter.			Years.			Range.
		Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
Superior City	8	2.018	0.245	1.285	1.765	0.685	1.281	2.026	0.388	1.298	2.371	0.393	1.336	2.371	0.245	1.301	2.126
Ontonagon	8	1.929	0.214	1.300	1.789	0.412	1.293	2.054	0.314	1.312	2.439	0.359	1.319	2.430	0.214	1.306	2.216
Marquette	8½	1.957	0.284	1.257	1.734	0.619	1.265	2.157	0.355	1.279	2.421	0.312	1.263	2.421	0.284	1.226	2.178
Milwaukee	8⅔	1.999	0.447	1.320	1.730	0.770	1.351	2.040	0.549	1.361	2.503	0.529	1.384	2.503	0.447	1.357	2.056
Grand Haven	4	1.867	0.499	1.342	1.694	0.695	1.358	1.974	0.588	1.380	2.248	0.352	1.393	2.248	0.352	1.369	1.896
Thunder Bay Island	7	1.984	0.050	1.318	1.824	0.732	1.357	2.129	0.421	1.364	2.069	0.519	1.358	2.129	0.050	1.355	2.079
Tawas	9	1.981	0.059	1.318	1.900	0.627	1.347	2.132	0.441	1.376	2.611	0.472	1.374	2.611	0.059	1.353	2.552
Detroit	8½	1.958	0.469	1.318	1.782	0.680	1.349	2.099	0.637	1.397	2.630	0.566	1.401	2.630	0.469	1.366	2.161
Monroe	8¼	1.990	0.600	1.343	1.854	0.704	1.309	2.059	0.670	1.436	2.641	0.548	1.428	2.641	0.548	1.326	1.093
Cleveland	8½	1.894	0.535	1.267	1.776	0.628	1.316	2.022	0.512	1.349	2.509	0.528	1.359	2.504	0.512	1.322	1.992
Buffalo	8¼	2.007	0.390	1.314	1.875	0.679	1.346	2.145	0.429	1.379	2.526	0.493	1.384	2.526	0.390	1.370	2.136
Fort Niagara	7⅓	2.400	0.828	1.704	2.224	1.104	1.723	2.617	0.876	1.762	2.957	0.958	1.755	2.957	0.828	1.741	2.129
Charlotte	8¼	2.355	0.679	1.662	2.202	0.970	1.662	2.553	0.767	1.720	2.989	0.892	1.741	2.989	0.679	1.728	2.310
Sackett's Harbor	8⅓	2.357	0.767	1.661	2.207	1.088	1.665	2.566	0.888	1.711	2.949	0.836	1.734	2.949	0.767	1.688	2.182

Maximum, minimum, and mean temperature for months.

	Number of years.	January.			February.			March.			April.			May.			June.		
		Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
Superior City	8	53	—37	12.1	55	—38	14.3	69	—24	22.5	70	—5	36.6	92	15	46.8	96	29	55.9
Ontonagon	8	45	—34	16.1	48	—37	13.5	61	—22	21.7	78	—5	37.3	94	18	47.7	97	30	59.5
Marquette	8	51	—31	17.9	53	—33	18.3	63	—19	24.5	74	3	33.8	93	16	50.3	100.5	30	61.0
Milwaukee	8	50	—30	21.2	56	—18	25.0	69	— 7	31.5	76	16	43.2	91	27	52.6	97	39	64.7
Grand Haven	4	65	— 5	25.8	52	—16	25.5	63	1	33.0	76	8	45.2	88	27	56.1	88	38	65.4
Thunder Bay Island	7	47	—17	22.7	47	—25	22.7	49	—11.5	28.5	62	8	37.0	72	25	46.5	90	35	57.2
Tawas	9	50	—25	21.6	57	—25	23.7	56	—10	30.3	61	9	40.0	81	17	50.9	90	27	62.2
Detroit	9	63	—19	27.4	64	—14	28.4	75	5	34.5	89	12	46.4	87	25	57.6	95	38	66.2
Monroe	8	73	—17	25.4	61	—19	28.7	75	— 7.5	34.2	78	19	46.9	92	29	58.2	101	38	69.7
Cleveland	8	66	—14	26.2	71	—14	29.9	76	6	35.3	84	17	47.7	91	28	57.7	95	39	68.4
Buffalo	8	60	—13	24.1	63	—22	28.4	67	— 2	31.4	77	12	43.8	86	23	53.7	96	28	65.0
Fort Niagara	8	50	— 9	26.0	60	—15	28.7	63	3	31.0	75	14	41.1	82	18	51.3	90	40	63.8
Charlotte	8	64	—15	25.8	58	—20	27.9	66	— 2	33.0	77	7	44.7	84	13	51.0	93	32	66.3
Sackett's Harbor	8	54	—16	21.1	59	—16	24.2	60	— 3.4	30.4	73	7	43.9	81	25	54.5	89	38	65.2

Maximum, minimum, and mean temperature for months—Continued.

	Number of years.	July.			August.			September.			October.			November.			December.		
		Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
Superior	9	99	35	64.0	97	33	63.7	88	21	54.5	84	15	43.2	66	—19	30.4	49	—31	13.8
Ontonagon	8	97	30	64.4	98	33	63.7	90.5	20	56.0	88.5	4	43.4	69	— 4	33.0	53	—20	21.8
Marquette	9	103	33	65.2	100	38	64.8	93	23	56.8	85	15	45.1	69	— 4	33.6	60.5	—19	21.5
Milwaukee	9	97	44	69.2	97	41	67.5	91	31	61.3	80	27	48.8	69	— 3	37.9	59	—19	25.2
Grand Haven	4	90	33	70.1	91	48	70.3	81	28	60.4	75	17	49.8	62	9	38.0	57	0	28.7
Thunder Bay Island		90	41	64.1	93	40	65.6	81	33	57.7	72.5	26	46.3	60.5	8	36.9	51	— 5	26.0
Tawas	9	86	33.5	67.6	87	31.5	66.8	85	28	59.1	75	20	47.8	59	11	37.1	60	— 6	25.5
Detroit	8	95	43	70.5	98	37	69.2	91	31	61.8	82	23	50.3	77	7	39.3	65	— 4	29.3
Monroe	9	103	41	74.0	99	34	72.3	98	27	63.7	89	24	57.9	71	5	40.5	59	—13	29.1
Cleveland	9	97	48	72.2	93	43	71.1	88	35	63.9	85	30	52.3	75	5	41.8	68	— 9	30.3
Buffalo	9	93	45	69.6	94	39	68.7	90	28	61.3	80	24	50.9	73	9	40.1	61	— 9	28.4
Fort Niagara	9	93	51	69.7	89	46	69.0	88	33	60.9	82	25	50.2	70	12	39.7	63	— 8	28.3
Charlotte	9	98	38	70.6	96	35	69.9	92	26	62.3	84	17	50 7	73	4	40.7	66	—22	29.2
Sackett's Harbor	9	91	48	70.1	93	43	69.0	88	28	61.8	82	23	50.0	73	8	38.7	61	—30	25.7

Maximum, minimum, and mean temperature for seasons and years.

	Number of years.	Spring.			Summer.			Autumn.			Winter.			Years.			Range.
		Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
Superior	8½	92	—24	35.3	99	29	61.2	88	—19	43.0	55	—38	13.7	99	—38	38.2	137
Ontonagon	8	94	—22	35.6	98	30	62.5	90.5	— 4	44.1	53	—37	17.3	98	—37	39.8	135
Marquette	8½	93	—19	36.2	103	30	63.7	93	— 4	45.2	60.5	—33	19.3	103	—33	41.1	136
Wilwaukee	8½	91	— 7	42.4	97	39	67.1	91	— 3	49.3	59	—30	23.8	97	—30	46.9	127
Grand Haven	4	88	1	44.8	91	28	68.6	81	9	49.4	65	—16	26.7	91	—16	47.6	107
Thunder Bay Island	7	72	—11.5	37.0	93	35	62.3	81	8	47.0	51	—25	23.8	93	—25	42.5	118
Tawas	9	81	—10	40.4	90	27	65.5	85	11	48.0	60	—25	23.6	90	—25	44.4	115
Detroit	8½	89	5	46.2	98	37	68.6	91	7	50.5	65	—19	27.7	98	—19	48.4	117
Monroe	8½	92	— 7.5	46.4	103	34	72.0	98	5	52.0	73	—19	27.7	103	—19	49.5	121
Cleveland	8½	91	6	46.9	97	39	70.6	88	5	52.7	71	—14	28.9	97	—14	48.9	111
Buffalo	8½	86	— 2	42.6	96	28	67.8	90	9	50.8	63	—22	26.5	96	—22	46.9	118
Fort Niagara	8½	82	3	41.1	93	40	67.5	88	12	50.3	63	—15	27.2	93	—15	46.4	108
Charlotte	8½	84	— 3	42.9	98	32	68.9	92	4	51.2	66	—22	27.7	98	—22	47.5	120
Sackett's Harbor	8½	81	—34	42.9	93	36	68.1	88	8	50.2	61	—46	24.0	93	—36	41.7	129

Yearly means and range of barometric pressure, reduced to 32° Fahr. + 28 inches.

	1859.		1860.		1861.		1862.		1863.		1864.		1865.		1866.		1867.	
	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.
Superior City	.....	(1.327)	1.276	1.544	1.274	1.724	1.324	1.355	1.322	1.585	1.288	1.315	1.308	1.487	1.318	1.766	1.292	1.485
Ontonagon	.....	1.306	1.302	1.538	1.282	1.715	1.323	1.441	1.332	1.504	1.252	1.476	.....	.....	.....	.....	1.311	1.550
Marquette	.....	.....	1.271	1.598	1.268	1.673	1.289	1.622	1.313	1.421	1.179	1.428	1.252	1.650	1.259	1.987	1.256	1.534
Thunder Bay Island	1.358	2.019	1.321	1.503	1.335	1.444	1.309	1.429	1.375	1.458	1.312	1.520	(1.389)	.....	.....	.....	.....	.....
Tawas City	1.368	2.073	1.342	1.465	1.341	1.444	1.376	1.475	1.399	1.389	1.314	1.598	1.384	1.483	1.348	2.139	1.299	1.378
Milwaukee	.....	.....	1.358	1.492	1.345	1.511	1.377	1.393	1.379	1.129	1.307	1.418	1.373	1.222	1.370	1.888	1.326	1.628
Grand Haven	.....	.....	1.353	1.560	1.346	1.527	1.360	1.434	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Detroit	.....	.....	1.352	1.426	1.347	1.293	1.370	1.376	1.373	1.395	1.330	1.411	1.394	1.327	1.413	1.966	1.379	1.468
Monroe	.....	.....	1.395	1.413	1.392	1.313	1.429	1.398	1.410	1.364	1.335	1.404	1.401	1.323	1.393	2.041	1.371	1.413
Cleveland	.....	.....	1.317	1.442	1.308	1.285	1.331	1.385	1.343	1.340	1.267	1.465	1.338	1.413	1.341	1.970	1.331	1.500
Buffalo	.....	.....	1.367	1.354	1.357	1.653	1.382	1.481	1.397	1.610	1.282	1.564	1.379	1.437	1.346	2.033	1.329	1.344
Fort Niagara	.....	.....	.....	.....	1.707	1.530	1.746	1.712	1.749	1.494	1.683	1.310	1.739	1.573	1.771	1.979	1.781	1.340
Charlotte	.....	.....	1.665	1.405	1.679	1.783	1.707	1.608	1.749	1.787	1.641	1.659	1.738	1.652	1.715	2.164	1.709	1.607
Sackett's Harbor	.....	.....	1.675	1.456	1.683	1.636	1.710	1.689	1.737	1.732	1.632	1.516	1.703	1.459	1.703	2.182	1.688	1.559

Yearly mean and range temperature.

	1859.		1860.		1861.		1862.		1863.		1864.		1865.		1866.		1867.	
	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.
Superior City	.....	.....	39.2	120	38.1	120	37.6	121	39.0	132	38.8	134	39.3	120	37.4	130	37.4	109
Ontonagon	.....	.....	40.3	110	40.5	132	38.6	119	40.3	103	40.6	132	.....	.....	.....	.....	39.2	.....
Marquette	.....	.....	41.0	109	41.0	130	40.1	121	41.8	120	42.7	132	43.3	112.5	40.8	126	41.9	119.5
Thunder Bay Island	41.3	84	41.7	82	42.6	107	42.9	95	42.9	87	43.2	113	(43.8)	93.5	.....	.....	.....	.....
Tawas City	44.4	89	44.7	95	44.5	110	43.9	95	44.1	96	44.3	108	44.7	95	43.4	.....	44.6	.....
Milwaukee	.....	.....	46.8	99	46.6	113	45.5	114	46.6	103	44.9	127	46.0	103	44.4	115	45.3	110
Grand Haven	.....	.....	47.3	86	47.4	107	47.2	94	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Detroit	.....	.....	47.8	103	48.7	112	48.3	94	48.4	94	48.1	114	49.3	96	46.0	106	46.8	107
Monroe	.....	.....	48.7	104	49.3	108	49.6	101	49.4	104	49.5	117	50.6	105	49.4	124	50.9	115
Cleveland	.....	.....	49.8	87	50.4	104	49.4	89	49.5	88	49.5	108	50.9	101	49.2	111	49.7	97
Buffalo	.....	.....	47.1	93	47.4	109	47.6	93	47.5	94	46.8	105	47.4	103	45.5	93	46.0	90
Fort Niagara	.....	.....	46.2	86	46.5	103	47.0	83	46.5	82	46.9	100	47.0	88	46.4	96	45.1	86
Charlotte	.....	.....	47.5	90	47.3	110	47.8	94	48.4	107	48.8	111	49.3	115	47.6	120	48.3	106
Sackett's Harbor	.....	.....	46.3	108	45.0	131	45.8	100	47.1	127	48.4	116	48.4	129	47.2	118	45.1	120

Mean monthly [illegible] at the United States, as shown from observations for months, seasons, and years.

	Number of years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Spring.	Summer.	Autumn.	Winter.	Year.
Superior	8 5-12	0.83	1.58	1.30	1.96	2.53	3.08	3.41	2.93	3.69	2.20	1.17	0.84	6.04	9.69	7.08	3.18	26.04
Ontonagon	8	2.51	1.33	1.28	1.62	2.02	2.37	2.23	2.42	2.51	2.22	1.25	2.37	4.92	7.02	6.22	6.30	25.16
Marquette	8½	2.08	2.10	1.85	2.02	1.88	3.04	2.73	2.91	2.75	2.54	2.51	2.13	5.78	8.35	7.82	6.29	29.05
Milwaukee	8	2.26	1.82	2.00	2.45	3.53	2.65	3.42	2.41	3.30	2.29	1.93	1.98	8.05	8.76	7.45	6.12	30.48
Grand Haven	4	1.62	1.98	1.16	1.06	3.11	1.68	2.22	3.67	2.60	2.39	2.79	1.73	5.33	8.59	7.72	4.64	25.32
Thunder Bay Island	7	3.90	2.65	2.83	3.07	2.07	2.33	2.86	2.25	3.84	2.79	2.45	2.89	7.97	7.44	9.08	8.25	33.23
Tawas	9	1.49	0.91	2.06	2.91	1.75	1.86	1.79	2.37	2.36	1.98	1.86	1.44	6.01	6.03	6.19	3.94	21.42
Detroit	8½	1.38	1.39	2.55	1.38	2.56	2.94	3.05	3.66	3.13	2.55	2.03	1.65	7.46	6.85	7.71	4.99	28.23
Monroe	8½	1.55	1.62	2.53	2.64	2.85	2.67	3.19	3.17	3.55	2.27	2.40	2.18	8.02	9.22	7.95	5.45	30.73
Cleveland	8½	2.94	2.31	1.74	3.27	3.39	3.20	3.02	2.98	3.83	3.26	3.53	3.24	9.67	9.38	10.24	8.74	37.83
Buffalo	8½	2.15	1.79	2.08	2.54	3.20	1.68	2.48	3.14	3.61	2.96	2.30	2.77	8.63	7.46	7.78	6.75	32.15
Fort Niagara	8½	2.09	1.94	2.37	2.07	2.64	1.48	2.70	2.36	2.46	2.61	2.53	2.21	6.57	6.81	7.31	6.37	26.80
Charlotte	8½	1.84	1.91	2.27	2.19	3.02	2.18	2.85	2.67	2.78	2.89	2.93	2.28	7.49	7.58	7.95	6.10	29.06
Sackett's Harbor	8½	1.78	2.57	2.67	2.96	3.65	2.29	2.88	2.90	3.37	3.79	3.87	2.67	9.28	8.18	10.70	7.40	35.81

I also give the maxima, minima, and mean of the barometer and thermometer, and the amount of rain since the commencement of the observations.

The following table gives the mean temperature for each of the places grouped according to their latitudes:

Stations.	Latitude.	Longitude.	Temperature.	
			Mean.	Range.
	° ′ ″	° ′ ″		
Ontonagon	46 52 30	89 30 30	39.2	135
Superior	46 46 30	92 03 28	38.2	137
Marquette	46 32 51	87 22 57	41.1	136
Thunder Bay island	45 02 13	83 02 34	42.5	118
Tawas City	44 15 57	83 30 54	44.4	115
Sackett's Harbor	43 55 00	75 57 00	41.7	129
Fort Niagara	43 15 00	79 55 00	46.4	108
Charlotte	43 12 54	77 51 00	47.5	129
Grand Haven	43 05 00	86 12 53	47.6	107
Milwaukee	43 03 00	87 55 00	46.9	127
Buffalo	42 53 00	78 55 00	46.9	118
Detroit	42 19 58	83 00 00	48.4	117
Monroe City	41 53 36	83 19 26	49.5	121
Cleveland	41 30 00	81 47 00	48.9	111

In the following table the stations are grouped according to their elevation above the sea and the mean and range of the barometer given:

Stations.	Height above the sea.	Barometer + 28 in.	
		Mean.	Range.
	Feet.		
Marquette	710	1.226	2.178
Superior	660	1.301	2.126
Ontonagon	630	1.306	2.216
Cleveland	629	1.322	1.992
Thunder Bay island	610	1.355	2.079
Milwaukee	604	1.357	2.056
Grand Haven	588	1.369	1.896
Tawas City	583	1.353	2.552
Buffalo	569	1.370	2.136
Detroit	562	1.366	2.161
Monroe City	551	1.326	2.093
Charlotte	272.5	1.728	2.310
Sackett's Harbor	265.6	1.688	2.182
Fort Niagara	262.5	1.741	2.129

There are several curious anomalies in this table, but none of much consequence.

Kaemtz, in his Meteorology, states that the iso-barometric line of 1.066 inch cuts the east coast of America at 46° 58′ north latitude, and that of 0.888 at 41° 40′. That is, the amplitude of the barometer, or difference between the maxima and minima, would be equal to the above quantities in the latitudes named. As these were about the limits of the places of observation on the lakes, I have constructed the following tables of the monthly amplitude of the barometer at the several stations for the different years. As the observations were only taken tri-daily, we have not, of course, the true maxima and minima, and therefore the amplitude given is smaller than the true amplitude of the places.

Table showing the amplitude of the barometer for each month and year at the several lake survey meteorological stations.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Milwaukee, Wis.													
1859	.....	.....	.....	.....	.....	.....	.....	0.448	0.910	0.826	1.239	0.996	.....
1860	1.245	1.341	1.050	1.488	0.844	0.871	0.781	0.486	0.849	1.034	1.091	1.192	1.492
1861	1.198	1.132	1.133	0.773	1.306	0.591	0.612	0.455	0.711	1.128	0.972	1.119	1.511
1862	0.960	1.232	0.978	0.964	0.839	0.614	0.576	0.650	0.642	1.000	1.124	1.121	1.393
1863	0.898	1.081	0.828	0.978	0.720	0.787	0.494	0.720	0.833	1.229	1.034	0.996	1.229
1864	0.991	1.276	0.987	0.590	0.607	0.724	0.557	0.654	0.647	0.860	0.990	1.418	1.418
1865	0.733	0.979	1.015	1.092	0.682	0.620	0.634	0.504	0.693	0.781	1.256	1.172	1.242
1866	1.820	0.994	1.168	0.789	0.834	0.795	0.581	0.644	0.714	1.208	1.142	1.277	1.888
1867	1.077	1.147	0.999	0.716	0.694	0.772	0.530	0.556	0.659	1.021	1.102	1.428	1.628
Mean	1.115	1.148	1.020	0.924	0.816	0.722	0.596	0.566	0.740	1.010	1.106	1.185	1.473
Grand Haven, Mich.													
1859	.....	.....	.....	.....	.....	.....	.....	.....	0.868	0.792	1.276	1.289	.....
1860	1.119	1.223	0.967	1.299	1.116	0.937	0.768	0.510	0.847	0.747	1.019	1.404	1.560
1861	1.225	1.365	1.328	0.879	1.138	0.490	0.701	0.437	0.762	1.029	1.038	0.912	1.527
1862	0.941	1.125	0.893	0.846	0.831	0.702	0.513	0.656	0.640	0.872	1.324	1.221	1.434
1863	0.940	0.990	0.832	0.976	0.753	0.781	0.508	.....	.....	.....	.....	.....	.....
Mean	1.056	1.176	1.005	1.000	0.959	0.727	0.617	0.534	0.779	0.860	1.164	1.206	1.507
Superior, Wis.													
1859	.....	.....	.....	.....	.....	.....	.....	0.622	0.909	0.945	1.327	1.188	.....
1860	1.447	1.088	1.169	1.393	0.961	0.887	0.988	0.570	1.136	0.993	1.221	1.012	1.544
1861	1.111	1.155	1.290	0.929	1.503	0.632	0.613	0.525	1.121	1.008	1.117	1.103	1.724
1862	0.862	0.969	0.907	0.907	0.704	0.761	0.688	0.759	0.861	1.353	1.175	1.279	1.355
1863	1.118	1.369	0.956	1.151	0.780	0.765	0.591	0.612	0.812	1.585	1.257	1.069	1.385
1864	1.160	1.009	1.011	0.591	0.775	0.736	0.545	0.812	0.736	0.917	1.230	1.315	1.315
1865	0.737	1.082	1.013	1.633	0.781	0.696	0.775	0.626	0.833	0.888	1.308	1.595	1.487
1866	1.359	1.205	1.312	1.136	0.873	0.968	0.840	0.759	0.756	1.125	1.231	1.206	1.766
1867	1.035	1.245	0.947	0.809	0.794	0.824	0.662	0.576	1.047	0.953	1.230	1.447	1.485
Mean	1.104	1.140	1.077	1.069	0.896	0.785	0.713	0.651	0.912	1.085	1.233	1.246	1.508
Ontonagon, Mich.													
1859	.....	.....	.....	.....	.....	.....	.....	0.655	0.948	0.808	1.306	0.882	.....
1860	1.314	1.317	1.166	1.367	0.887	1.268	1.041	0.657	1.093	0.982	1.278	1.141	1.538
1861	1.139	1.203	1.427	0.916	1.683	0.876	0.563	0.576	1.137	1.032	1.211	1.117	1.715
1862	1.789	0.952	1.030	0.736	0.687	0.678	0.658	0.709	0.934	1.255	1.115	1.227	1.441
1863	1.045	1.379	1.054	1.083	0.777	1.010	0.610	0.582	0.817	1.495	1.198	1.252	1.504
1864	1.193	1.067	0.957	0.612	0.842	0.948	0.717	0.803	0.812	1.380	1.197	1.338	1.476
1865	1.351	0.977	1.038	1.496	0.818	0.709	0.731	0.553	0.674	1.027	1.503	1.359	1.631
1866	1.515	1.205	1.284	1.054	0.898	0.898	0.700	0.763	0.871	1.326	1.261	1.314	1.865
1867	1.056	1.236	0.958	0.771	0.772	0.696	0.003	0.694	0.929	1.203	1.206	1.550	1.550
Mean	1.300	1.167	1.114	1.034	0.920	0.885	0.603	0.666	0.913	1.168	1.253	1.242	1.525
Marquette, Mich.													
1859	.....	.....	.....	.....	.....	.....	0.892	0.551	0.960	1.081	1.405	0.862	.....
1860	1.230	1.234	1.163	1.341	0.859	0.814	0.922	0.646	1.139	1.135	1.304	1.200	1.598
1861	1.148	1.106	1.462	1.041	1.466	0.783	0.621	0.641	1.089	1.044	1.260	1.218	1.673
1862	1.037	1.031	1.102	1.031	0.728	0.757	0.620	0.673	0.796	1.178	1.315	1.155	1.622
1863	1.010	1.275	1.065	1.036	0.790	1.115	0.667	0.770	0.860	1.352	1.069	1.155	1.421
1864	1.150	1.119	1.057	0.628	0.745	0.776	0.621	0.722	0.754	0.885	1.071	1.428	1.428
1865	0.815	0.836	1.038	1.292	0.857	0.739	0.733	0.628	0.732	0.854	1.499	1.269	1.650
1866	1.691	1.241	1.266	1.002	0.782	0.892	0.603	0.721	0.890	1.376	1.190	1.198	1.987
1867	0.980	1.184	1.137	0.815	0.690	0.778	0.743	0.564	0.917	1.121	1.063	1.534	1.534
Mean	1.133	1.128	1.161	1.023	0.865	0.832	0.714	0.635	0.904	1.114	1.242	1.224	1.614
Thunder Bay Island, Mich.													
1859	0.957	1.173	1.829	1.218	0.975	0.833	0.971	0.464	1.086	0.709	1.410	1.100	2.019
1860	1.191	1.239	1.039	1.503	0.839	0.911	0.901	0.749	0.895	1.054	1.171	1.326	1.503
1861	1.222	1.173	1.304	1.003	1.163	0.766	0.732	0.536	0.850	1.179	1.027	1.097	1.449
1862	1.001	1.041	0.932	1.160	0.772	0.856	0.633	0.743	0.924	1.082	1.316	1.126	1.423

Table showing the amplitude of the barometer, &c.—Continued.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1863	1.330	1.192	1.006	1.173	0.859	0.984	0.568	0.747	0.945	1.086	1.094	1.272	1.458
1864	1.091	1.182	1.272	0.782	0.588	1.013	0.505	0.827	0.745	0.793	1.369	1.422	1.580
1865	0.799	0.889	1.354	1.395	0.910	0.652	0.721	0.604	0.529	1.157	1.113	.....	.....
Mean	1.084	1.127	1.248	1.176	0.872	0.859	0.717	0.668	0.853	1.008	1.214	1.224	1.563
Tawas City, Mich.													
1859	1.058	0.837	1.840	1.176	0.958	0.878	0.908	0.444	1.049	0.689	1.442	1.058	2.073
1860	1.058	1.236	0.962	1.411	0.820	1.006	0.869	0.647	0.868	0.779	1.099	1.549	1.465
1861	1.219	1.199	1.244	0.956	1.160	0.714	0.727	0.513	0.804	1.143	0.992	1.065	1.444
1862	1.212	1.124	0.940	1.008	0.907	0.835	0.723	0.726	0.826	4.928	1.284	1.158	1.475
1863	1.301	1.302	0.862	1.186	0.889	0.962	0.581	0.682	0.837	1.064	1.031	1.271	1.389
1864	1.092	1.154	1.202	0.792	0.585	0.870	0.482	0.732	0.707	0.976	1.357	1.460	1.586
1865	0.925	1.098	1.244	1.329	0.894	0.637	0.708	0.622	0.588	1.125	1.355	0.986	1.483
1866	1.788	1.055	1.110	0.896	0.801	0.847	0.671	0.764	0.715	1.172	0.638	1.452	2.129
1867	1.175	1.096	1.054	0.903	0.854	0.805	0.779	0.593	0.628	1.122	0.738	1.373	1.378
Mean	1.203	1.122	1.162	1.073	0.874	0.842	0.728	0.647	0.780	1.022	1.104	1.264	1.603
Detroit, Mich.													
1859	1.076	0.753	1.352	1.041	0.758	.....	.....	.....	.....	.....	.....	1.199	.....
1860	1.038	1.195	0.759	1.396	0.695	1.004	0.678	0.669	0.694	0.908	0.993	1.238	1.436
1861	1.150	1.084	1.038	0.959	1.037	0.540	0.646	0.439	0.782	1.043	0.915	0.950	1.293
1862	1.110	1.117	0.766	0.996	0.768	0.849	0.620	0.523	0.724	0.918	1.150	1.187	1.376
1863	1.292	1.169	0.952	1.120	0.849	0.823	0.506	0.730	0.835	1.024	0.987	1.161	1.395
1864	0.974	1.228	1.107	0.767	0.584	0.800	0.483	0.734	0.570	0.668	1.098	1.305	1.411
1865	0.867	1.042	1.164	0.962	0.660	0.531	0.602	0.455	0.614	1.035	1.312	1.255	1.327
1866	0.786	1.040	1.000	0.900	0.990	0.914	0.587	0.739	0.755	0.965	1.192	1.300	1.966
1867	0.976	1.468	1.049	0.866	0.950	0.708	0.552	0.509	0.568	1.038	0.999	1.308	1.468
Mean	1.141	1.122	1.021	0.996	0.810	0.771	0.584	0.600	0.693	0.950	1.082	1.210	1.458
Monroe, Mich.													
1859	.....	.....	.....	.....	.....	.....	0.718	0.383	0.838	0.820	1.009	1.103	.....
1860	1.193	1.257	0.843	1.242	0.726	0.954	0.742	0.605	0.703	0.920	0.937	1.214	1.413
1861	1.290	1.029	1.077	0.900	1.048	0.414	0.616	0.501	0.809	1.030	0.897	0.951	1.313
1862	1.106	1.178	0.849	0.900	0.766	0.742	0.603	0.576	0.718	0.723	0.940	1.146	1.288
1863	1.322	1.162	0.888	1.045	0.875	0.747	0.651	0.656	0.859	0.972	0.885	1.309	1.364
1864	0.957	1.198	1.053	0.703	0.553	0.786	0.455	0.623	0.568	0.681	1.142	1.297	1.404
1865	0.903	1.025	1.107	0.976	0.775	0.433	0.698	0.472	0.642	0.985	1.234	1.087	1.323
1866	1.760	1.026	1.023	0.861	1.075	0.807	0.526	0.725	0.652	0.842	1.197	1.222	2.041
1867	0.967	1.411	0.979	0.954	0.956	0.694	0.572	0.561	0.590	1.040	1.077	1.243	1.413
Mean	1.178	1.161	0.977	0.948	0.847	0.697	0.620	0.567	0.709	0.890	1.035	1.181	1.458
Cleveland, Ohio.													
1859	.....	.....	.....	.....	.....	0.655	0.698	0.412	0.859	0.796	1.055	1.000	.....
1860	1.004	1.088	0.805	1.347	0.687	0.943	0.683	0.552	0.704	0.699	1.055	1.009	1.442
1861	1.161	0.980	0.948	0.935	1.014	0.527	0.536	0.561	0.854	0.945	0.968	0.992	1.265
1862	0.992	1.109	0.875	0.971	0.637	0.773	0.756	0.576	0.665	0.665	1.046	0.985	1.265
1863	1.164	1.193	0.862	1.063	0.859	0.720	0.517	0.666	0.739	0.927	0.807	1.229	1.340
1864	0.983	0.970	1.112	0.685	0.594	0.778	0.556	0.679	0.634	0.616	1.209	1.465	1.465
1865	1.045	1.031	1.081	0.930	0.948	0.512	0.679	0.520	0.561	1.030	1.193	1.028	1.413
1866	1.736	1.032	0.913	1.025	0.946	0.806	0.563	0.703	0.664	0.667	1.214	1.251	1.970
1867	0.977	1.500	0.946	0.930	0.995	0.758	0.452	0.440	0.578	0.960	0.833	1.062	1.500
Mean	1.133	1.112	0.943	0.986	0.835	0.719	0.604	0.568	0.695	0.812	1.044	1.119	1.477
Buffalo, N. Y.													
1859	.....	.....	.....	.....	.....	.....	0.828	0.588	0.902	0.679	1.103	1.156	.....
1860	0.923	1.283	0.792	1.327	0.648	1.068	0.586	0.526	0.803	0.771	1.075	1.292	1.354
1861	0.293	1.184	1.003	0.963	1.317	0.497	0.528	0.431	1.018	0.994	0.892	0.994	1.653
1862	1.107	1.100	0.889	1.000	0.619	0.872	0.741	0.600	0.870	0.770	1.261	1.231	1.421
1863	1.463	1.319	1.001	1.231	0.883	0.743	0.504	0.687	0.841	0.882	0.944	1.454	1.610
1864	1.201	1.092	1.091	0.659	0.544	0.889	0.468	0.679	0.687	0.835	1.416	1.448	1.564
1865	0.993	1.041	1.194	0.939	0.803	0.557	0.648	0.648	0.536	1.180	1.121	0.919	1.437
1866	1.602	1.187	1.080	1.113	0.957	0.816	0.535	0.570	0.746	0.953	1.381	1.489	2.033
1867	0.948	1.344	1.011	0.955	0.972	0.691	0.561	0.539	0.652	1.035	1.015	1.246	1.344
Mean	1.191	1.194	1.008	1.023	0.843	0.767	0.600	0.585	0.784	0.899	1.134	1.248	1.562

Table showing the amplitude of the barometer, &c.—Continued.

Year.	January.	February.	March.	April.	May	June.	July.	August.	September.	October.	November.	December.	Year.
Fort Niagara, N. Y.													
859	.....	.....	.....	.....	.....	.....	0.654	0.449	0.998	.....	.....	.....	.....
860	.....	.....	.....	.....	.....	.....	0.595	0.578	0.888	0.046	1.052	1.423	.....
861	1.343	1.205	1.100	1.085	1.185	0.541	0.676	0.602	1.179	0.979	0.848	1.089	1.530
862	1.308	1.052	1.029	0.994	0.633	0.915	0.734	0.771	0.831	0.990	1.409	1.256	1.712
863	1.487	1.170	1.119	0.844	0.848	0.863	0.600	0.623	0.946	0.948	0.960	1.487	1.494
864	1.056	1.103	1.239	0.653	0.716	0.815	0.562	0.727	0.673	0.872	1.360	1.330	1.310
865	1.055	1.065	1.243	1.092	0.946	0.641	0.767	0.628	0.736	1.358	1.253	0.907	1.573
866	1.709	1.202	1.002	1.088	0.866	0.912	0.708	0.626	0.748	0.980	1.464	1.508	1.979
867	1.056	1.211	1.061	1.183	0.942	0.814	0.631	0.684	0.934	1.063	1.040	1.153	1.340
Mean	1.287	1.144	1.113	0.991	0.877	0.786	0.658	0.632	0.881	1.017	1.174	1.269	1.563
Charlotte, N. Y.													
859	.....	.....	.....	.....	.....	.....	0.922	0.523	0.974	0.718	1.298	1.176	.....
860	0.942	1.199	0.952	1.276	0.808	0.987	0.648	0.606	0.876	0.824	1.013	1.357	1.405
861	1.369	1.301	1.067	1.020	1.390	0.639	0.586	0.516	0.898	1.063	0.873	0.949	1.783
862	1.352	1.238	0.989	1.053	0.698	0.908	0.596	0.685	0.912	0.873	1.402	1.315	1.608
863	1.416	1.395	1.086	1.320	0.904	0.845	0.525	0.700	0.923	0.984	1.190	1.473	1.787
864	1.371	1.157	0.917	0.686	0.643	0.933	0.546	0.766	0.746	0.998	1.487	1.471	1.659
865	1.094	1.147	1.309	1.167	0.925	0.581	0.772	0.680	0.531	1.358	1.259	0.893	1.632
866	1.773	1.246	1.443	1.242	1.052	0.878	0.625	0.723	0.801	0.963	1.510	1.429	2.164
867	1.049	1.297	1.073	1.056	1.063	0.871	0.642	0.549	0.791	1.085	1.015	1.354	1.607
Mean	1.296	1.247	1.054	1.102	0.935	0.830	0.646	0.639	0.828	0.985	1.227	1.266	1.708
Sackett's Harbor, N. Y.													
859	.....	.....	.....	.....	.....	.....	0.962	0.552	1.007	1.129	1.294	1.165	.....
860	0.925	1.243	0.921	1.264	0.871	0.939	0.689	0.666	0.930	0.907	1.073	1.418	1.456
861	1.221	1.435	1.094	1.056	1.271	0.656	0.590	0.562	1.286	1.054	0.941	1.052	1.636
862	1.484	1.114	0.943	0.956	0.696	0.913	0.734	0.700	0.799	0.897	1.321	1.282	1.689
863	1.389	1.475	1.129	1.295	0.868	0.805	0.545	0.597	0.941	0.900	0.968	1.505	1.732
864	1.387	1.163	1.192	0.639	0.593	0.911	0.580	0.728	0.795	1.103	0.965	1.201	1.516
865	0.944	1.211	1.327	1.068	0.886	0.550	0.686	0.703	0.569	1.163	0.949	1.061	1.459
866	1.683	1.217	0.897	1.386	1.015	0.756	0.609	0.625	0.809	0.988	.....	1.324	2.182
867	1.144	1.359	1.160	0.894	1.152	0.692	0.696	0.507	0.658	1.022	0.922	1.213	1.559
Mean	1.272	1.302	1.083	1.070	0.919	0.778	0.655	0.627	0.866	1.016	1.054	1.250	1.654

In the following table I have given the mean amplitude for the seasons and year:

Table showing the mean amplitude of the barometer for the seasons and year at the several lake survey meteorological stations.

Stations.	Latitude.	Longitude.	Mean amplitude of barometer.				
			Spring.	Summer.	Autumn.	Winter.	Year.
	° ′ ″	° ′ ″					
Ontonagon	46 52 30	89 33 30	1.013	0.751	1.111	1.236	1.035
Superior	46 46 30	92 03 28	1.014	0.716	1.077	1.163	0.992
Marquette	46 32 57	87 22 57	1.016	0.727	1.087	1.175	1.001
Thunder Bay Island	45 02 13	86 11 26	1.099	0.748	1.025	1.145	1.001
Tawas City	44 15 57	83 30 54	1.036	0.739	0.969	1.196	0.985
Sackett's Harbor	43 55 00	75 57 00	1.024	0.687	0.979	1.275	0.991
Fort Niagara	43 15 00	79 55 00	0.994	0.692	1.024	1.233	0.981
Charlotte	43 12 34	77 51 00	1.030	0.705	1.013	1.270	1.004
Grand Haven	43 05 00	86 12 33	0.988	0.626	0.934	1.146	0.923
Milwaukee	43 03 00	87 55 00	0.920	0.628	0.952	1.149	0.912
Buffalo	42 53 00	78 55 00	0.960	0.651	0.939	1.211	0.940
Detroit	42 19 58	83 00 00	0.942	0.652	0.908	1.158	0.915
Monroe	41 53 36	83 19 26	0.921	0.628	0.878	1.170	0.900
Cleveland	41 30 00	81 47 00	0.921	0.630	0.850	1.121	0.880

Kaemtz gives the amplitude for a few places on this continent for the winter, summer, and year, as follows:

	North latitude.	Longitude.	Winter.	Summer.	Year.
	° ′	° ′ ″			
New Harmony, Indiana	38 11	90 15 24	0.901	0.350	0.646
Fort Churchill, British America	58 47	96 24 24	1.210	0.740	0.886
New Haven, Connecticut	41 10	74 50 24	1.306	0.569	0.996
Cambridge, Massachusetts	42 23	74 37 24	1.267	0.676	1.010
Sitka, Russian America	57 03	140 20 24	1.019	0.677	0.965
Nain, Labrador	58 08	63 40 24	1.599	0.962	1.274

From these tables it will be seen that the iso-barometric line of 1.000 inch for the year on the eastern coast starts near Boston, runs somewhat northward, touching the southern coast of Lake Ontario and the southern coast of Lake Superior, and strikes the Pacific coast north of Sitka, in Russian America. The difference between the eastern and western sides of the continent is shown in the great difference in the amplitude of Nain, Labrador, on the one side and of Sitka on the other.

Thus the iso-barometric lines follow very nearly the same course as the iso-thermal lines across the continent.

In my work on the outflow of the lakes, I found it necessary to have the evaporation from the surface of the lakes.

Although evaporators had been kept for many years at several of the meteorological stations, the notes had never been worked up, and I therefore have given a good deal of my own time to these calculations.

The evaporators in use are made by James Green, of New York, and consist of a zinc vessel with vertical sides, of 100 square inches of surface, the height of the water in them being read by means of a screw with a micrometer head on one side of the vessel.

These of course could not be read in freezing weather, and it was therefore necessary to find some method of determining the amount of evaporation at such time.

In my last year's report I gave a table showing the relation of the evaporation to the humidity, temperature, &c., and I then showed the evaporation was most affected by changes in the relative humidity.

But the humidity being calculated from the readings of the psychrometer is very uncertain during the cold weather, as was shown in the curves of the hourly observations at Thunder Bay island.

I therefore examined more particularly the relation between the evaporation and temperature.

For this purpose tables similar to the following were constructed for each of the stations where evaporators were used:

Table showing the relation of the evaporation and temperatures at Milwaukee, Wis.

Date.	Monthly evaporation in inches.	Number of days observed.	Mean daily evaporation.	Mean temperature.	Ratio of evaporation to temperature.	Date.	Monthly evaporation in inches.	Number of days observed.	Mean daily evaporation.	Mean temperature.	Ratio of evaporation to temperature.
1861.						1864.					
November..	0.985	21	0.042	40.7	971	August....	4.670	31	0.151	69.9	463
1862.						September.	2.140	30	0.071	60.7	855
May.....	4.270	27	0.158	54.4	345	October...	1.260	31	0.041	45.7	1,115
June.....	5.367	30	0.179	60.8	396	November.	0.355	9	0.039	41.4	1,062
July.....	6.320	31	0.204	70.9	347	1865.					
August.....	5.321	27	0.197	69.7	354	April.....	1.300	9	0.144	45.7	317
September.	3.835	27	0.142	62.1	437	May.....	4.445	31	0.143	52.9	370
October...	2.730	31	0.088	51.1	581	June.....	4.495	29	0.156	67.5	433
1863.						July.....	5.115	31	0.165	63.4	384
April.....	3.296	25	0.131	45.3	346	August....	4.724	30	0.157	67.0	427
May.....	3.670	30	0.122	55.1	452	September.	2.389	30	0.079	68.4	866
June.....	5.335	30	0.178	63.7	364	1866.					
July.....	5.100	31	0.164	68.6	418	April.....	2.545	17	0.150	49.7	331
August.....	4.730	31	0.153	69.1	452	May.....	5.115	28	0.182	51.0	279
September.	4.055	30	0.135	59.4	440	June.....	5.125	27	0.189	63.6	337
October....	1.505	31	0.049	43.8	894	July.....	7.110	31	0.229	73.0	318
1864.						August....	4.200	31	0.135	66.1	490
April.....	1.982	24	0.079	39.7	502	September.	2.650	29	0.091	57.2	629
May.....	6.310	29	0.218	56.2	258	October...	2.210	30	0.074	50.5	655
June.....	7.135	30	0.238	65.2	281	November	1.315	26	0.051	39.7	778
July.....	5.380	31	0.173	71.3	412						

From this table it will be seen that for the month of November the evaporation is nearly one-thousandth of the temperature, and that in April it is about three times as great. This was nearly the same at all the places compared, and the mean ratios were of course more regular than shown in the above table. Now the evaporation in winter in this climate must be very small, much smaller than that of November; but as it rises so rapidly in April it is probable that the evaporation of March is comparatively large. So that if we take one-thousandths of the temperature as the evaporation for the winter months we cannot be far from the actual amount.

The following table was compiled according to that assumption. The evaporation where observed being given in common figures, and where computed as above, from the temperature, in old English:

Table showing the mean daily evaporation for each month, in decimals of an inch.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
Superior, Wis.													
1862	*0.009	*0.007	*0.023	*0.034	0.116	0.124	0.136	0.117	0.098	0.045	*0.027	*0.021	0.063
1863	*0.019	*0.014	*0.023	*0.039	0.120	0.175	0.135	0.190	0.095	0.046	*0.029	*0.020	0.075
1864	*0.014	*0.020	*0.023	*0.036	0.127	0.168	0.145	0.135	0.083	0.049	*0.029	*0.010	0.070
1865	*0.011	*0.019	*0.022	*0.035	0.127	0.130	0.159	0.135	0.134	0.052	*0.038	*0.011	0.073
1866	*0.010	*0.009	*0.017	*0.036	0.110	0.145	0.161	0.099	0.090	0.068	*0.031	*0.015	0.066
1867	*0.008	*0.013	*0.015	*0.039	0.103	0.172	0.183	0.159	0.082	0.058	*0.032	*0.012	0.074
Mean	*0.012	*0.014	*0.021	*0.036	0.117	0.152	0.153	0.139	0.097	0.053	*0.031	*0.016	0.070
Ontonagon, Mich.													
1861	.....	.....	.....	.....	.....	.....	.....	.....	0.100	0.074	*0.032	*0.019	.....
1862	*0.013	*0.008	*0.023	*0.035	*0.047	0.129	0.144	0.121	0.101	0.090	*0.030	*0.024	0.064
1863	*0.023	*0.018	*0.023	*0.042	*0.052	0.136	0.110	0.074	0.090	0.101	*0.031	*0.023	0.062
1864	*0.015	*0.020	*0.022	*0.036	*0.050	0.200	0.202	0.093	0.085	0.083	*0.031	*0.016	0.075
1865	*0.015	*0.021	*0.022	*0.036	0.119	0.183	.....	.....	.....	.....	.....	.....	.....
Mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

*Old English figures in the original giving the evaporation as computed from the mean temperature.

Table showing the mean daily evaporation for each month in decimals of an inch—Continued.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
Milwaukee, Wis.													
1861													
1862	*0.020	*0.019	*0.032	0.112	0.158	0.179	0.204	0.197	0.142	0.088	*0.038	*0.031	0.102
1863	*0.030	*0.032	*0.031	0.131	0.122	0.178	0.164	0.153	0.135	0.049	*0.040	*0.029	0.091
1864	*0.019	*0.026	*0.031	0.079	0.218	0.238	0.173	0.151	0.071	0.041	*0.039	*0.021	0.090
1865	*0.019	*0.027	*0.032	0.144	0.143	0.156	0.165	0.157	0.079	0.060	*0.044	*8.023	0.097
1866	*0.020	*0.019	*0.027	0.150	0.182	0.189	0.229	0.135	0.091	0.074	*0.051	*0.023	0.098
1867	*0.017	*0.027	*0.026	0.114	0.098	0.210	0.231	0.218	0.155	0.095	0.073	*0.026	0.107
Mean	*0.021	*0.025	*0.030	0.122	0.153	0.192	0.194	0.169	0.112	0.068	*0.047	*0.025	0.096
Tawas, Mich.													
1861									0.059	0.045	*0.047	*0.032	
1862	*0.021	*0.021	*0.029	*0.039	0.144	0.165	0.171	0.172	0.098	0.064	*0.035	*0.030	0.092
1863	*0.028	*0.025	*0.028	*0.040	0.151	0.148	0.167	0.122	0.101	0.072	*0.037	*0.028	0.079
1864	*0.022	*0.026	*0.028	*0.039	0.203	0.205	0.226	0.216	0.139	0.101	*0.036	*0.023	0.106
1865	*0.019	*0.023	*0.031	*0.042	0.216	0.224	0.210	0.236	0.170	0.157	*0.039	*0.026	0.108
Mean	*0.022	*0.024	*0.029	*0.040	0.179	0.185	0.193	0.187	0.113	0.088	*0.039	*0.028	0.094
Thunder Bay Island, Mich.													
1861								0.184	0.119	0.121	0.105	*0.032	
1862	*0.023	*0.020	*0.030	0.130	0.140	0.205	0.187	0.228	0.147	0.155	0.075	*0.030	0.114
1863	*0.028	*0.024	*0.026	0.141	0.136	0.197	0.200	0.158	0.128	0.084	0.100	*0.028	0.105
1864	*0.022	*0.024	*0.026	0.137	0.141	0.191	0.187	0.199	0.119	0.082	0.080	*0.024	0.103
1865	*0.019	*0.024	*0.030	0.155	0.151	0.150	0.192	0.183	0.140	0.149	0.122	*0.026	0.111
Mean	*0.023	*0.023	*0.028	0.141	0.142	0.186	0.194	0.190	0.131	0.118	0.096	*0.028	0.108
Detroit, Mich.													
1861	*0.024	*0.030	*0.031	0.141	0.162	0.220	0.238	0.168	0.111	0.063	0.042	*0.035	0.107
1862	*0.024	*0.025	*0.032	0.133	0.207	0.191	0.202	0.230	0.134	0.095	0.050	*0.033	0.113
1863	*0.032	*0.027	*0.031	0.145	0.207	0.184	0.191	0.158	0.122	0.081	0.042	*0.032	0.104
1864	*0.025	*0.029	*0.033	0.134	0.182	0.240	0.214	0.199	0.111	0.048	0.038	*0.026	0.107
Mean	*0.026	*0.033	*0.032	0.138	0.189	0.204	0.211	0.189	0.119	0.072	0.043	*0.032	0.108
Monroe, Mich.													
1863	*0.031	*0.028	*0.032	0.095	0.200	0.202	0.197	0.208	0.123	0.074	0.075	*0.033	0.108
1864	*0.026	*0.031	*0.033	0.085	0.182	0.244	0.230	0.173	0.120	0.068	*0.039	*0.027	0.105
1865	*0.023	*0.029	*0.039	0.126	0.161	0.219	0.161	0.161	0.141	0.087	*0.040	*0.029	0.101
1866	*0.024	*0.026	*0.032	0.199	0.188	0.205	0.203	0.140	0.099	0.076	*0.041	*0.028	0.103
1867	*0.024	*0.034	*0.032	0.144	0.144	0.208	0.186	0.180	0.130	0.104	*0.043	*0.029	0.105
Mean	*0.026	*0.030	*0.034	0.130	0.175	0.218	0.195	0.172	0.123	0.082	*0.047	*0.029	0.105
Cleveland, Ohio.													
1861							0.180	0.162	0.105	0.059	0.048	*0.037	
1862	*0.027	*0.027	*0.033	0.129	0.166	0.162	0.192	0.195	0.125	0.077	0.065	*0.035	0.103
1863	*0.032	*0.029	*0.032	0.104	0.187	0.188	0.159	0.163	0.081	0.050	0.040	*0.034	0.092
1864	*0.027	*0.030	*0.035	0.087	0.128	0.158	0.172	0.129	0.080	0.042	0.048	*0.028	0.080
1865	*0.021	*0.027	*0.039	0.091	0.125	0.165	0.138	0.113	0.082	0.053	0.031	*0.032	0.076
1866	*0.026	*0.028	*0.033	0.126	0.124	0.159	0.173	0.104	0.062	0.051	0.034	*0.026	0.079
1867	*0.021	*0.035	*0.032	0.104	0.100	0.141	0.161	0.158	0.113	0.055	0.042	*0.029	0.083
Mean	*0.026	*0.029	*0.034	0.107	0.138	0.162	0.168	0.146	0.093	0.055	0.044	*0.032	0.086

* Old English figures in the original, giving the evaporation as computed from the mean temperature.

The evaporators used are generally placed on top of the meteorological house, or in some place near, where they are fully exposed to the sun. The temperature of the water in them is therefore much greater than that of the lake, and the evaporation proportionally larger. I, last year,

attempted to make comparisons between an evaporator in the usual position and one in the water.

Unavoidable accidents prevented many observations from being made, but the results obtained show that the lake evaporation is not over 64 per cent. of that shown by the instruments on land.

I hope to make further and more careful experiments to test this point the coming season. I would have changed the position of the different evaporators last year, but I thought it better to let them work as usual, and to use a correction for their readings, the same for the future as for the past.

According to the above correction the following table was compiled:

Sixty-four per cent. was taken of the mean daily evaporation for each year at the several places given in the preceding table. This will be found in the first column; in the second is the daily rain-fall for each year; third, the ratio of the two; fourth, the mean temperature; and fifth, the ratio between the temperature and the evaporation.

Table showing the corrected daily evaporation, daily amount of rain, and mean temperature at the several lake-survey meteorological stations for different years.

SUPERIOR CITY, WISCONSIN.

Year.	Daily evaporation.	Daily rain.	Ratio of rain and evaporation.	Mean temperature.	Ratio of temperature and evaporation.
1862.....	0.040	0.062	1.55	37.6	940
1863.....	0.048	0.047	0.97	39.0	812
1864.....	0.045	0.057	1.27	38.8	866
1865.....	0.046	0.082	1.80	39.3	847
1866.....	0.042	0.071	1.70	37.4	882
1867.....	0.045	0.077	1.72	37.4	835
Mean ...	0.044	0.066	1.50	38.2	864

CLEVELAND, OHIO.

1862.....	0.066	0.113	1.73	49.4	752
1863.....	0.074	0.100	1.36	49.5	672
1864.....	0.064	0.094	1.46	49.5	774
1865.....	0.061	0.090	1.47	50.9	837
1866.....	0.063	0.132	2.09	49.2	779
1867.....	0.066	0.093	1.40	49.7	749
Mean ...	0.066	0.104	1.59	49.7	760

DETROIT, MICHIGAN.

1861.....	0.069	0.105	1.52	48.7	707
1862.....	0.072	0.886	1.20	48.3	671
1863.....	0.066	0.083	1.25	48.4	729
1864.....	0.069	0.071	1.02	48.1	699
Mean ...	0.069	0.086	1.24	48.4	701

ONTONAGON, MICHIGAN.

1862.....	0.041	0.074	1.81	38.6	946
1863.....	0.040	0.064	1.60	40.3	1,007
1864.....	0.048	0.063	1.31	40.6	846
Mean ...	0.043	0.067	1.57	39.8	933

MILWAUKEE, WISCONSIN.

Year.	Daily evaporation.	Daily rain.	Ratio of rain and evaporation.	Mean temperature.	Ratio of temperature and evaporation.
1862....	0.066	0.107	1.62	45.5	694
1863....	0.058	0.089	1.52	45.6	797
1864....	0.058	0.076	1.32	44.9	779
1865....	0.056	0.082	1.46	46.0	821
1866....	0.060	0.091	1.46	44.4	711
1867....	0.070	0.068	0.97	45.7	656
Mean ..	0.062	0.086	1.39	45.5	743

MONROE, MICHIGAN.

1863....	0.069	0.084	1.22	49.4	717
1864....	0.067	0.080	1.19	49.5	736
1865....	0.065	0.091	1.40	50.6	781
1866....	0.067	0.085	1.24	49.4	735
1867....	0.067	0.072	1.07	50.9	757
Mean ..	0.067	0.082	1.22	50.0	745

TAWAS, MICHIGAN.

1862....	0.053	0.068	1.29	43.9	812
1863....	0.050	0.085	1.69	44.1	875
1864....	0.068	0.052	0.76	44.3	644
1865....	0.069	0.075	1.07	44.7	649
Mean ..	0.060	0.070	1.20	44.2	744

THUNDER BAY ISLAND, MICHIGAN.

1862....	0.073	0.101	1.39	42.9	589
1863....	0.067	0.086	1.27	42.9	639
1864....	0.066	0.087	1.32	43.2	659
1865....	0.071	0.086	1.21	43.8	615
Mean ..	0.069	0.090	1.30	43.2	622.

From this table it will be seen that there is a somewhat regular ratio between the evaporation and rain-fall, the mean being about the same for all latitudes. But it is not nearly as regular as the relation existing in each place between the mean temperature and the evaporation, and which ratio decreases with the latitude with only one exception of importance, when the paucity of the observations are taken into account. This will be better seen in the following table, where the stations are arranged according to the latitude and the means of the previous table given:

Table showing the mean daily evaporation, amount of rain, and temperature at the several lake-survey meteorological stations.

Stations.	Latitude.	Longitude.	Daily evaporation.	Daily rain.	Ratio of rain and evaporation.	Mean temperature.	Ratio of temperature and evaporation.
	° ′ ″	° ′ ″					
Ontonagon	46 52 30	89 33 30	0.043	0.067	1.57	39.8	933
Superior	46 46 30	92 03 28	0.044	0.066	1.50	38.2	864
Thunder Bay Island	45 02 13	86 11 26	0.069	0.090	1.30	43.2	622
Tawas	44 15 57	83 30 54	0.060	0.070	1.20	44.2	744
Milwaukee	43 03 00	87 55 00	0.062	0.086	1.39	45.5	743
Detroit	42 19 58	83 00 00	0.069	0.086	1.24	48.4	701
Monroe	41 53 36	83 19 26	0.067	0.082	1.22	50.0	745
Cleveland	41 30 00	81 47 00	0.066	0.104	1.59	49.7	760

This gives us a means of computing the evaporation with considerable accuracy where the rain-fall, temperature, and latitude are known. From the foregoing table we find the evaporation

Of Lake Superior is equal to	0.0436	inche.
Of Lake Michigan is equal to	0.0616	"
Of Lake Huron is equal to	0.0668	"
Of Lake Erie is equal to	0.0672	"

but we have no observations on Lake Ontario.

Computing the evaporation by dividing the mean temperature of the three stations on the lake by the ratio of evaporation and temperature given in the above table for the corresponding latitude, we find it to be equal to 0.0631 inche. Again, taking the mean of the ratio of the rain-fall and evaporation and dividing the mean rain-fall of the lake by it, the result is 0.0632—rather a curious coincidence, but it shows that with a sufficient number of observations this method of computing evaporation would be practically accurate.

The records of the water gauges have not been reduced since 1863, and a great deal of the work previous to that time was so done that it had to be reviewed. The first thing was the comparison of the zeros of the gauges to get a common plane of reference.

Now, the winds have great influence on the height of the water at any place, and also generally a contrary influence to that at a place situated on another part of the lake. Thus, on Lake Erie, when there is a southwest wind the water is blown away from Monroe and heaps up at Buffalo, while at Cleveland it does not change much, and at Erie less than at Buffalo. By the direct comparison of the readings of the several gauges through the year the differences would be very varying, and though the mean might be nearly correct, yet it would be uncertain, therefore it

was thought best to attempt to eliminate the action of the wind as much as possible. To do this, what I call the bi-five-day means, that is the mean of five days on each side of every fifth day, or a ten-day mean every five days, were taken. Then, for the comparisons of the zeros, only the calm months of June, July, and August were used.

The comparisons of Buffalo with Cleveland are given in the accompanying table:

Table of the comparisons of the zeros of the water gauges at Cleveland, Ohio, and Buffalo, New York.

Date.	1859.			1860.			1861.			1862.		
	Cleveland.	Buffalo.	Difference.	Cleveland.	Buffalo.	Difference.	Cleveland.	Buffalo.	Difference.	Cleveland.	Buffalo.	Difference.
June 1–10	.....	.....	.....	3.88	3.95	0.07	.....	.....	.....	.....	.....	.....
6–15	3.37	3.60	0.23	3.84	4.00	0.16	3.69	4.04	0.36	3.64	3.94	0.30
11–20	3.31	3.43	0.12	3.80	4.11	0.31	3.68	3.95	0.27	3.63	3.86	0.23
16–25	3.18	3.44	0.26	3.78	4.24	0.46	3.72	4.01	0.29	3.58	3.84	0.26
21–30	3.32	3.38	0.06	3.88	4.18	0.30	3.79	3.98	0.19	3.60	3.83	0.23
26– 5	3.34	3.45	0.11	3.99	4.22	0.23	3.81	4.02	0.21	3.64	3.76	0.12
July 1–10	3.43	3.63	0.20	4.02	4.41	0.39	3.86	4.08	0.23	3.59	3.71	0.12
6–15	3.52	3.66	0.14	4.06	4.28	0.22	3.88	4.11	0.23	3.57	3.62	0.05
11–20	3.54	3.61	0.07	4.13	4.14	0.01	3.95	4.12	0.17	3.62	3.76	0.14
16–25	3.60	3.57	—0.03	4.16	3.89	—0.27	4.02	4.15	0.03	3.63	3.83	0.20
21–31	3.72	3.66	—0.06	4.16	3.90	—0.26	4.09	4.14	0.05	3.70	3.80	0.10
26– 5	3.76	3.79	0.03	4.17	4.14	—0.03	4.08	4.16	0.08	3.82	3.87	0.05
Aug. 1–10	3.75	3.78	0.03	4.19	4.09	—0.10	.....	.....	.....	3.86	3.87	0.01
6–15	3.71	3.92	0.21	4.18	4.21	0.03	.....	.....	.....	3.91	3.94	0.03
11–20	3.68	4.07	0.39	4.17	4.35	0.18	.....	.....	.....	4.01	4.16	0.15
16–25	3.77	4.02	0.25	4.23	4.37	0.14	3.94	4.16	0.22	4.11	4.27	0.16
21–31	3.92	3.97	0.05	4.30	4.35	0.05	4.04	4.14	0.10	4.17	4.17	0.00
26– 5	4.06	3.99	—0.07	.....	.....	.....	4.03	4.14	0.11	4.20	4.10	0.10
Mean diff'ce	.....	.....	0.12	.....	.....	0.10	.....	.....	0.19	.....	.....	0.13

Table of the comparisons of the zeros of the water gauges, &c.—Continued.

Date.	1863.			1864.			1865.			1866.			1867.		
	Cleveland.	Buffalo.	Difference.	Cleveland.	Buffalo.	Difference.	Cleveland.	Buffalo.	Difference.	Cleveland.	Buffalo.	Difference.	Cleveland.	Buffalo.	Difference.
June 1–10	4.14	4.29	0.15	4.30	4.48	0.18	4.96	5.19	0.23	5.02	5.28	0.26	4.46	4.23	0.23
6–15	4.14	4.40	0.26	4.39	4.57	0.18	4.95	5.35	0.40	5.06	5.12	0.06	4.41	4.19	0.22
11–20	4.20	4.46	0.26	4.45	4.71	0.26	4.94	5.31	0.37	5.00	5.08	0.08	4.41	4.09	0.32
16–25	4.22	4.43	0.21	4.52	4.67	0.15	4.99	5.19	0.20	4.95	5.04	0.09	4.40	4.16	0.24
21–30	4.20	4.52	0.32	4.55	4.61	0.06	.....	.....	.....	4.85	4.95	0.10	4.47	4.16	0.31
26– 5	4.20	4.61	0.41	4.55	4.63	0.08	.....	.....	.....	4.76	4.86	0.10	4.59	4.20	0.39
July 1–10	4.22	4.58	0.36	4.59	4.74	0.15	5.04	5.06	0.02	4.80	4.95	0.15	4.60	4.28	0.32
6–15	4.25	4.67	0.42	4.60	4.81	0.21	5.04	5.23	0.19	4.89	4.99	0.10	4.59	5.18	0.41
11–20	4.33	4.76	0.43	4.64	4.81	0.17	5.08	5.27	0.19	4.86	5.08	0.22	4.61	4.32	0.29
16–25	4.34	4.70	0.36	4.72	4.87	0.15	5.04	5.28	0.24	4.82	5.11	0.29	4.66	4.42	0.24
21–31	4.32	4.52	0.20	4.83	4.89	0.06	5.00	5.17	0.17	4.87	5.09	0.22	4.70	4.30	0.40
26– 5	4.34	4.52	0.18	4.89	4.94	0.05	5.04	5.22	0.18	.....	.....	.....	4.74	4.37	0.37
Aug. 1–10	4.30	4.58	0.28	4.87	4.96	0.09	5.10	5.26	0.16	.....	.....	.....	4.80	4.50	0.30
6–15	4.29	4.50	0.21	4.93	5.04	0.11	5.10	5.27	0.17	5.00	5.22	0.22	4.84	4.59	0.25
11–20	4.32	4.57	0.25	4.98	5.09	0.11	5.08	5.38	0.30	5.03	5.30	0.28	4.94	4.73	0.21
16–25	4.39	4.59	0.20	4.94	5.01	0.07	5.08	5.42	0.34	5.12	5.26	0.24	5.00	4.79	0.21
21–31	4.39	4.61	0.22	.....	.....	.....	5.16	5.39	0.23	5.22	5.29	0.07	5.06	4.83	0.23
26– 5	4.49	4.79	0.30	5.07	5.17	0.10	5.25	5.33	0.08	5.24	5.45	0.21	5.13	4.88	0.25
Mean difference	.....	.....	0.28	.....	.....	0.12	.....	.....	0.22	.....	.....	0.17	.....	.....	0.29

The mean difference of the zeros for	1859	was..... 0.12
Do ..... do	1860	..... 0.10
Do ..... do	1861	..... 0.19
Do ..... do	1862	..... 0.13
Do ..... do	1863	..... 0.28
Do ..... do	1864	..... 0.12
Do ..... do	1865	..... 0.22
Do ..... do	1866	..... 0.17
Do ..... do	1867	..... 0.29
Mean		..... 0.18

Therefore the zero of the Buffalo gauge is 0.18 feet above the zero o the Cleveland gauge.

Very fortunately for these comparisons the remarkably high stage water in the summer of 1838 was generally noticed, and on three of t lakes referred to permanent beach-marks. These were at Charlott Lake Ontario, by Professor Dewey; at Cleveland, Lake Erie, by Colon Whittlesey, and at Milwaukee, Lake Michigan, by Dr. Lapham. W thus have a common plane of reference on three of the lakes and c easily compare them and the others.

Following out the example above given, the zero of Buffalo is 0.18 fe above that of Cleveland, but the zero of Cleveland is 2.92 feet above t high water of 1838, therefore the zero of Buffalo is 2.74 feet above t same. In the same manner the zeros at all the stations were compar and referred to a common plane.

Comparisons were also made between the zeros of the stations on t different lakes where the water of 1838 was noted.

The mean difference between the readings at Cleveland and Charlot and Cleveland and Milwaukee thus compared, and those taken by dire reference to the several beach-marks, was less than a quarter of a fo though the water in Lake Ontario varies very much in different years

The bi-five day means are given in the accompanying tables for all the stations except those on Lake Superior. These are unavoidab omitted, the reductions of the self-registering gauges not being co pleted.

Bi-five day means of the depressions of the water surface below the common plane of ref ence, (the high water of June, 1838,) in feet and decimals.

MILWAUKEE, WISCONSIN.

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.	Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	[illegible]
1859.							1861.						
August.....	.....	.....	.....	.....	1.09	1.19	March.....	.....	2.40	2.63	2.67	2.56	2.
September..	1.32	1.38	1.23	1.14	1.28	1.43	April.....	2.16	2.30	2.31	2.27	2.22	2.
October.....	1.44	1.41	1.54	1.53	1.48	1.57	May.....	1.91	1.89	1.75	1.69	1.71	1.
November...	1.62	1.61	1.65	1.56	1.69	1.81	June.....	1.49	1.52	1.51	1.44	1.45	1.
December...	1.88	2.11	1.84	1.78	1.94	2.08	July.....	1.46	1.45	1.47	1.50	1.39	1.
1860.							August.....	1.41	1.29	1.34	1.49	1.61	1.
January.....	2.10	2.14	2.22	2.20	2.21	2.10	September..	1.65	1.65	1.57	1.54	1.70	1.
February....	2.08	2.03	2.00	1.97	1.92	2.01	October....	1.71	1.79	1.87	1.89	2.00	1.
March.....	1.98	1.90	1.94	2.00	2.04	1.96	November..	2.04	2.04	2.03	2.03	2.15	2.
April.....	1.95	1.97	1.99	1.85	1.87	1.92	December..	2.14	2.15	2.27	2.16	2.14	2.
May.....	1.85	1.79	1.79	1.73	1.67	1.68	1862.						
June.....	1.69	1.65	1.62	1.63	1.65	1.60	January....	2.27	2.46	2.48	2.33	2.34	2.
July.....	1.52	1.56	1.63	1.69	1.68	1.63	February..	2.52	2.56	2.50	2.45	2.52	2.
August.....	1.66	1.69	1.68	1.65	1.63	1.69	March.....	2.37	2.30	2.14	2.09	2.12	2.
September..	1.66	1.75	1.96	2.08	2.09	2.04	April.....	2.38	2.19	2.27	2.26	2.20	2.
October.....	2.07	2.11	2.16	2.14	2.13	2.22	May.....	2.07	2.02	1.90	1.88	1.82	1.
November...	2.30	2.32	2.64	2.82	2.81	2.68	June.....	1.73	1.75	1.71	1.67	1.67	1.
December...	2.67	2.81	2.85	2.70	2.79	2.89	July.....	1.78	1.78	1.69	1.69	1.75	1.
1861.							August.....	1.64	1.54	1.52	1.51	1.49	.....
January.....	2.83	2.81	2.80	2.73	2.92	3.00	September	.....	1.54	1.43	1.48	1.57	1.
February....	2.85	2.66	2.64	2.77	2.81	.....	October....	1.89	1.85	1.89	2.04	2.01	2.

Bi-five day means of the depressions of the water surface, &c.—Continued.

MILWAUKEE, WISCONSIN.

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1862.						
November...	2.34	2.45	2.40	2.36	2.45	2.46
December...	2.59	2.48	2.44	2.48	2.44	2.52
1863.						
January.....	2.59	2.61	2.54	2.54	2.56	2.52
February....	2.46	2.51	2.58	2.51	2.50	2.48
March.....	2.58	2.66	2.55	2.48	2.43	2.67
April.....	2.73	2.60	2.54	2.44	2.38	2.25
May.....	2.17	2.20	2.18	2.27	2.19	2.21
June.....	2.21	2.23	2.23	2.23	2.22	2.18
July.....	2.12	2.22	2.15	2.30	2.32	2.19
August.....	2.32	2.21	2.51	2.76	2.73	2.72
September...	2.70	2.56	2.45	2.48	2.45	2.49
October.....	2.73	2.86	2.67	2.56	2.61	2.67
November...	2.72	2.58	2.51	2.57	2.62	2.80
December...	2.86	2.76	2.78	2.84	2.82	3.03
1864.						
January.....	3.29	3.11	2.98	3.00	2.93	2.68
February....	2.81	3.06	3.34	3.36	3.16	3.10
March.....	2.95	2.74	2.83	3.08	2.89	2.98
April.....	3.22	3.13	3.15	3.03	2.88	2.84
May.....	2.74	2.74	2.88	2.81	2.80	2.80
June.....	2.79	2.75	2.73	2.79	2.81	2.80
July.....	2.79	2.79	2.81	2.85	2.88	2.87
August.....	2.87	2.96	2.93	2.98	3.23	3.17
September...	3.08	3.23	3.37	3.40	3.39	3.39
October.....	3.48	3.55	3.60	3.67	3.59	3.59
November...	3.78	3.86	.....	3.91	3.82	3.75
December...	3.81	3.86	3.90	3.91	4.05	4.17
1865.						
January.....	4.11	4.15	4.15	4.05	4.13	4.19
February....	4.15	4.11	4.05	4.05	3.94	3.97
March.....	4.08	4.02	3.97	3.73	3.56	3.64
April.....	3.82	3.78	3.67	3.60	3.39	3.31
May.....	3.28	3.26	3.03	2.66	.....	2.52

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1865.						
June.....	2.55	2.73	2.69	2.66	2.68	2.78
July.....	2.90	2.91	2.78	3.03	3.42	3.17
August.....	2.83	2.87	2.89	2.85	2.71	2.75
September..	2.83	2.89	2.91	2.89	2.67	2.96
October....	2.93	2.99	2.92	2.77	2.97	....
November..	3.70	3.65	3.60	3.63	3.58	3.74
December..	3.91	3.93	3.84	3.97	4.13	4.15
1866.						
January....	4.27	4.41	4.04	4.05	4.27	4.29
February..	4.40	4.52	4.43	4.54	4.54	4.34
March.....	4.40	4.47	4.38	4.34	4.42	4.45
April.....	.....	.....	.....	.....	.....	.....
May.....	3.26	3.32	3.37	3.38	3.39	3.53
June.....	3.56	3.61	3.65	3.73	3.81	3.84
July.....	3.81	3.67	3.67	3.75	3.79	3.71
August.....	3.74	3.79	3.82	3.86	3.81	3.72
September..	3.68	3.60	3.61	3.73	3.67	3.60
October....	3.57	3.59	3.58	3.43	3.48	3.61
November..	3.47	3.42	3.45	3.46	3.47	3.45
December..	.....	3.66	3.76	3.75	3.69	3.91
1867.						
January....	3.90	3.73	3.62	3.70	3.87	3.91
February..	3.96	3.86	3.71	3.61	3.64	3.73
March.....	3.72	3.71	3.69	3.53	3.45	3.35
April.....	3.32	3.24	3.31	3.34	3.32	3.36
May.....	3.32	3.22	2.98	3.98	.....	.....
June.....	.....	.....	.....	.....	2.73	2.74
July.....	2.64	2.61	2.50	2.55	2.67	2.68
August.....	2.68	2.65	2.65	2.72	2.75	2.76
September..	2.84	2.94	2.93	2.94	2.91	2.93
October....	3.05	3.11	3.20	3.28	3.24	3.35
November..	3.66	3.75	3.86	3.70	3.64	3.64
December..	.....	.....	.....	.....	.....	.....

GRAND HAVEN, MICHIGAN.

1859.						
January.....	.....	.....	.....	.....	.....	.....
February.....	.....	.....	.....	.....	.....	.....
March.....	.....	.....	.....	.....	.....	.....
April.....	.....	.....	.....	.....	.....	.....
May.....	.....	.....	.....	.....	.....	.....
June.....	.....	.....	.....	.....	.....	.....
July.....	.....	.....	.....	.....	.....	.....
August.....	.....	.....	1.12	1.10	1.25	
September..	1.36	1.35	1.27	1.20	1.20	1.30
October.....	1.41	1.46	1.53	1.54	1.52	1.61
November...	1.70	1.61	1.64	1.64	1.60	1.56
December ..	1.61	1.86	*	*	*	*
1860.						
January.....	.....	.....	.....	.....	.....	.....
February.....	.....	.....	.....	.....	.....	.....
March.....	.....	1.72	1.82	1.90	1.99	1.96
April.....	1.82	1.84	1.88	1.79	1.82	1.88
May.....	1.83	1.77	1.78	1.75	1.66	1.64
June.....	1.64	1.59	1.62	1.64	1.64	1.61
July.....	1.46	1.52	1.65	1.70	1.71	1.71
August.....	1.74	1.78	1.87	1.86	1.81	1.85
September..	1.78	1.84	1.96	2.00	2.08	2.12
October.....	2.10	2.13	2.20	2.22	2.20	2.16
November...	2.21	2.33	2.32	2.31	2.47	2.57
December...	2.67	2.87	*	*	*	*
1861.						
January.....	.....	.....	.....	.....	.....	.....
February.....	.....	.....	.....	.....	.....	.....
March.....	.....	.....	.....	.....	.....	1.94
April.....	1.84	1.99	2.15	2.18	2.12	2.00
May.....	1.88	1.78	1.72	1.69	1.68	1.59
June.....	1.49	1.52	1.52	1.47	1.46	1.50

1861.						
July.....	1.49	1.42	1.42	1.51	1.42	1.23
August.....	1.19	1.18	1.18	1.25	1.35	1.37
September..	1.44	1.53	1.52	1.49	1.48	1.43
October....	1.49	1.56	1.55	1.65	1.74	1.74
November..	1.82	1.86	1.83	1.75	1.82	2.02
December..	2.03	2.08	2.15	2.14	2.17	2.17
1862.						
January.....	.....	.....	.....	.....	.....	.....
February.....	.....	.....	.....	.....	.....	.....
March.....	.....	.....	.....	.....	.....	.....
April.....	1.51	1.42	1.83	1.94	1.90	1.88
May.....	1.90	1.91	1.88	1.70	1.58	1.62
June.....	1.59	1.65	1.60	1.49	1.49	1.63
July.....	1.73	1.73	1.70	1.65	1.66	1.68
August.....	1.66	1.63	1.70	1.73	1.76	1.85
September..	1.79	1.72	1.72	1.77	1.83	1.76
October....	1.71	1.69	1.78	1.87	1.86	1.79
November..	1.81	1.91	1.94	1.95	2.00	2.04
December..	2.11	2.18	2.21	2.30	2.36	2.36
1863.						
January.....	.....	.....	.....	.....	.....	.....
February.....	.....	.....	.....	.....	.....	.....
March.....	.....	.....	2.43	2.38	2.20	2.24
April.....	2.37	2.40	2.40	2.30	2.21	2.15
May.....	2.13	2.11	2.10	2.13	2.10	2.08
June.....	2.07	2.09	2.10	2.08	2.08	2.10
July.....	2.11	2.12	2.18	2.18	2.15	.....
August.....	.....	.....	.....	.....	.....	.....
September..	.....	.....	.....	.....	.....	.....
October.....	.....	.....	.....	.....	.....	.....
November..	.....	.....	.....	.....	.....	.....
December..	.....	.....	.....	.....	.....	.....

* Gauge frozen.

† Gauge discontinued.

Bi-five day means of the depressions of the water surface, &c.—Continued.

THUNDER BAY ISLAND, MICHIGAN.

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1859.						
January	.....	.....	.....	.....	.....	.....
February	.....	.....	.....	.....	.....	.....
March	.....	.....	2.06	2.04	1.87	1.84
April	1.84	1.78	1.67	1.54	1.53	1.50
May	1.42	1.33	1.25	1.18	1.18	0.94
June	0.91	0.87	0.87	0.86	0.81	0.76
July	0.78	0.77	0.68	0.63	0.65	0.63
August	0.76	0.78	0.83	0.86	0.88	0.85
September	0.97	1.05	1.16	1.30	1.27	1.05
October	1.16	1.30	1.31	1.34	1.45	1.49
November	1.55	1.61	1.60	1.66	1.57	.....
December*	.....	.....	.....	.....	.....	.....
1860.						
January	.....	.....	.....	.....	.....	.....
February	.....	.....	.....	.....	.....	.....
March	.....	.....	.....	.....	.....	.....
April	1.95	1.92	1.89	1.93	1.89	1.93
May	1.94	1.92	1.88	1.84	1.83	1.77
June	1.70	1.65	1.63	1.64	1.63	1.67
July	1.67	1.59	1.55	1.52	1.54	1.60
August	1.57	1.62	1.77	1.87	1.85	1.68
September	1.58	1.57	1.57	1.60	1.66	1.80
October	1.84	1.84	1.92	2.04	2.11	2.09
November	2.08	2.14	2.13	2.08	.....	.....
December*	.....	.....	.....	.....	.....	.....
1861.						
January	.....	.....	.....	.....	.....	.....
February	.....	.....	.....	.....	.....	.....
March	.....	.....	.....	.....	.....	.....
April	.....	.....	.....	1.76	1.84	1.84
May	1.75	1.62	1.61	1.54	1.43	1.42
June	1.38	1.39	1.32	1.26	1.23	1.15

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1861.						
July	1.15	1.21	1.24	1.24	1.25	1.17
August	1.06	1.03	1.06	1.04	1.04	1.03
September	1.03	1.06	1.11	1.10	1.09	1.16
October	1.22	1.18	1.19	1.23	1.28	1.39
November	1.42	1.46	1.58	1.62	1.55	1.51
December	1.58	1.52	1.47	1.63	*	*
1862.						
January	.....	.....	.....	.....	.....	.....
February	.....	.....	.....	.....	.....	.....
March	.....	.....	.....	.....	.....	.....
April	.....	.....	1.98	1.83	1.75	1.71
May	1.63	1.60	1.60	1.50	1.44	1.47
June	1.46	1.44	1.43	1.41	1.41	1.38
July	1.35	1.34	1.37	1.33	1.27	1.32
August	1.29	1.20	1.21	1.29	1.34	1.33
September	1.32	1.34	1.38	1.33	1.31	1.35
October	1.27	1.23	1.23	1.22	1.38	1.53
November	1.61	1.63	1.70	1.75	1.78	1.82
December	1.85	1.91	1.91	1.96	2.05	2.02
1863.						
January	2.02	.....	.....	.....	.....	.....
February	.....	.....	.....	.....	.....	.....
March	.....	.....	.....	.....	.....	.....
April	.....	.....	2.39	2.33	2.22	2.18
May	2.11	1.95	1.82	1.80	1.85	1.89
June	1.70	1.70	1.75	1.79	1.83	1.85
July	1.82	1.85	1.91	1.94	1.89	1.84
August	.....	1.79	1.82	1.77	1.68	1.72
September	1.89	1.90	1.89	1.96	2.09	2.12
October	2.13	2.20	2.17	2.18	2.26	2.23
November	2.19	2.24	2.22	2.17	2.18	2.10
December	2.22	2.45	2.17	2.08	2.05	.....

TAWAS, MICHIGAN.

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1859.						
April	.....	.....	1.50	1.30	1.28	1.26
May	1.22	1.09	1.00	0.98	0.96	0.89
June	0.82	0.83	0.79	0.72	0.70	0.67
July	0.62	0.60	0.54	0.49	0.52	0.57
August	0.60	0.64	0.66	0.72	0.78	0.82
September	0.93	0.98	1.06	1.13	1.16	1.10
October	1.08	1.24	1.34	1.39	1.45	1.54
November	1.60	1.61	1.64	1.70	1.72	1.62
December	1.68	.....	.....	.....	.....	.....
1860.						
March	.....	.....	.....	.....	.....	1.50
April	1.51	1.48	1.47	1.42	1.39	1.43
May	1.43	1.39	1.31	1.32	1.31	1.32
June	1.15	1.13	1.14	1.16	1.17	1.15
July	1.10	1.05	1.05	1.04	1.02	1.08
August	1.09	1.06	1.14	1.19	1.21	1.25
September	1.27	1.28	1.33	1.40	1.42	1.51
October	1.58	1.58	1.65	1.71	1.81	1.88
November	1.83	1.84	1.90	1.97	.....	.....
December	.....	.....	.....	.....	.....	.....
1861.						
April	.....	.....	.....	1.93	1.86	1.73
May	1.69	1.59	1.46	1.39	1.31	1.26
June	1.23	1.19	1.15	1.09	1.03	1.02
July	1.05	1.02	1.01	1.01	0.99	0.91
August	0.88	0.88	0.92	0.94	0.93	0.97
September	0.93	0.93	1.03	1.03	1.00	1.08
October	1.17	1.17	1.17	1.24	1.33	1.37

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1861.						
November	1.39	1.42	1.51	1.59	1.61	1.59
December	1.63	1.63	1.56	1.57	.....	.....
1862.						
June	1.52	1.52	1.52	1.47	1.44	1.47
July	1.44	1.37	1.37	1.30	1.36	1.42
August	1.25	1.16	1.14	1.20	1.24	1.33
September	1.20	1.19	1.22	1.21	1.20	1.25
October	1.22	1.17	1.17	1.14	1.21	1.30
November	1.30	1.34	1 44	1.50	1.55	1.60
December	1.54	.....	.....	.....	.....	.....
1863.						
April	.....	.....	.....	.....	2.27	2.29
May	2.18	2.01	1.92	1.92	1.93	1.94
June	1.74	1.78	1.85	1.90	1.93	1.95
July	1.87	1.85	1.91	1.97	1.98	1.98
August	1.98	1.96	1.91	1.87	1.89	1.93
September	1.97	2.03	2.05	2.08	2.18	2.25
October	2.27	2.30	2.34	2.33	2.37	2.39
November	2.30	2.27	2.29	2.25	.....	.....
1864.						
May	.....	2.14	2.12	2.11	2.06	2.09
June	2.13	2.12	2.15	2.18	2.16	2.19
July	2.19	2.18	2.20	2.17	2.15	2.16
August	2.20	2.28	2.29	2.30	2.35	2.37
September	2.66	2.76	2.76	2.79	2.73	2.79
October	.....	.....	.....	.....	.....	.....
November	.....	.....	.....	.....	.....	.....

* Gauge frozen.

Bi-five day means of the depressions of the water surface, &c.—Continued.

POINT AUX BARQUES, MICHIGAN.

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.	Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1859.							1861.						
January	1.60	1.62	1.71	1.67	1.69	1.78	December	1.64	1.64	1.56	1.62	1.77	1.98
February	1.78	1.81	1.85	1.83	1.82	1.96	1862.						
March	1.97	1.93	1.74	1.77	1.67	1.74	January	2.18	2.07	1.89	1.99	2.05	2.03
April	1.69	1.62	1.59	1.40	1.20	1.23	February	2.03	2.06	2.07	2.07	2.03	2.11
May	1.18	1.08	1.01	0.96	0.89	0.81	March	8.19	2.10	2.10	2.10	2.12	2.18
June	0.74	0.75	0.73	0.67	0.64	0.58	April	2.10	2.05	2.00	1.77	1.68	1.71
July	0.57	0.57	0.48	0.46	0.46	0.47	May	1.62	1.59	1.59	1.50	1.47	1.47
August	0.57	0.59	0.61	0.66	0.69	0.67	June	1.42	1.43	1.43	1.42	1.43	1.42
September	0.81	0.84	0.88	0.98	0.98	0.98	July	1.39	1.39	1.42	1.39	1.36	1.39
October	0.97	1.09	1.12	1.10	1.17	1.24	August	1.38	1.34	1.34	1.44	1.50	1.48
November	1.30	1.33	1.30	1.42	1.45	1.35	September	1.49	1.60	1.71	1.71	1.68	1.61
December	1.38	1.40	1.52	1.46	1.45	1.57	October	1.41	1.25	1.25	1.26	1.37	1.51
1860.							November	1.53	1.58	1.68	1.75	1.79	1.82
January	1.63	1.71	1.69	1.66	1.62	1.66	December	1.82	1.89	1.92	2.02	2.11	2.11
February	1.67	1.69	1.71	1.67	1.72	1.68	1863.						
March	1.61	1.55	1.57	1.53	1.51	1.60	January	2.11	2.04	2.05	2.19	2.19	2.15
April	1.67	1.63	1.61	1.55	1.51	1.58	February	2.27	2.35	2.25	2.21	2.29	2.27
May	1.61	1.60	1.50	1.52	1.53	1.40	March	2.25	2.25	2.35	2.48	2.34	2.23
June	1.30	1.28	1.31	1.32	1.31	1.32	April	2.27	2.30	2.33	2.26	2.14	2.11
July	1.29	1.20	1.18	1.14	1.15	1.24	May	2.06	1.97	1.88	1.84	1.86	1.79
August	1.25	1.21	1.27	1.34	1.33	1.37	June	1.74	1.76	1.80	1.81	1.86	1.88
September	1.43	1.43	1.47	1.50	1.51	1.64	July	1.85	1.83	1.86	1.93	1.94	1.94
October	1.75	1.74	1.78	1.88	2.01	2.03	August	1.90	1.86	1.88	1.86	1.85	1.91
November	1.94	1.93	1.97	1.98	2.03	2.06	September	1.94	1.99	1.98	1.98	2.13	2.22
December	2.16	2.21	2.28	2.35	2.36	2.45	October	2.22	2.26	2.30	2.26	2.32	2.40
1861.							November	2.31	2.29	2.32	2.30	2.32	2.29
January	2.42	2.48	2.56	2.57	2.51	2.44	December	2.41	2.53	2.51	2.58	2.70	2.65
February	2.45	2.52	2.52	2.43	2.38	2.31	1864.						
March	2.22	2.26	2.32	2.33	2.38	2.48	January	2.61	2.69	2.67	2.74	2.88	2.79
April	2.45	2.20	1.99	1.93	1.90	1.76	February	2.78	2.82	2.77	2.66	2.68	2.67
May	1.67	1.60	1.46	1.41	1.33	1.26	March	2.72	2.69	2.62	2.74	2.87	2.82
June	1.24	1.21	1.14	1.11	1.07	1.03	April	2.72	2.61	2.50	2.47	2.39	2.25
July	1.02	1.06	1.04	1.02	1.01	0.95	May	2.18	2.13	2.09	2.09	2.06	2.06
August	0.88	0.92	0.96	0.94	0.91	0.93	June	2.06	2.06	2.12	2.15	2.12	2.12
September	0.96	1.01	1.03	1.01	1.00	1.09	July	2.16	2.17	2.16	2.11	2.13	2.20
October	1.16	1.13	1.15	1.26	1.35	1.35	August	2.21	2.24	2.25	2.29	2.31	2.30
November	1.39	1.46	1.54	1.68	1.65	1.56	September	2.51	2.63	2.59	2.62	2.63	.....

DETROIT, MICHIGAN.

1861.							1863.						
January	1.62	1.68	1.88	1.98	2.25	2.53	June	1.54	1.42	1.47	1.48	1.45	1.45
February	3.48	3.59	3.38	3.09	3.11	2.98	July	1.44	1.40	1.40	1.40	1.44	1.46
March	2.41	1.90	1.98	2.30	2.35	2.05	August	1.45	1.45	1.39	1.48	1.56	1.56
April	1.27	1.45	1.59	1.60	1.60	1.48	September	1.58	1.61	1.62	1.76	1.79	1.97
May	1.39	1.37	1.41	1.45	1.43	1.41	October	2.15	2.10	2.08	2.21	2.25	2.30
June	1.22	1.10	1.22	1.29	1.23	1.23	November	2.37	2.34	2.29	2.27	2.35	2.42
July	1.28	1.22	1.19	1.22	1.31	1.28	December	2.41	2.39	2.44	2.40	2.28	2.15
August	1.12	1.00	0.99	1.08	1.15	1.23	1864.						
September	1.22	1.27	1.29	1.22	1.34	1.40	January	2.01	1.98	1.99	2.15	2.49	2.75
October	1.29	1.44	1.53	1.50	1.61	1.70	February	2.75	2.71	2.85	2.79	2.70	2.72
November	1.54	1.55	1.64	1.63	1.67	1.72	March	2.65	2.55	2.70	2.87	2.60	2.35
December	1.64	1.63	1.62	1.54	1.64	1.70	April	2.16	2.03	1.96	1.89	1.79	1.83
1862.							May	1.91	1.69	1.46	1.36	1.30	1.30
January	1.60	1.65	1.77	2.24	2.55	2.65	June	1.29	1.30	1.27	1.36	1.55	1.51
February	2.85	2.99	3.20	3.20	3.21	3.19	July	1.46	1.48	1.62	1.58	1.73	1.71
March	3.02	2.60	1.96	1.70	1.56	1.33	August	1.58	1.73	1.90	1.90	1.92	2.01
April	0.93	0.95	1.16	1.09	0.92	0.92	September	1.90	1.83	1.91	2.03	2.13	2.11
May	1.01	1.00	1.00	1.05	1.01	0.95	October	2.30	2.55	2.58	2.55	2.53	2.59
June	0.96	1.01	0.99	0.96	0.97	0.98	November	2.70	2.66	2.43	2.43	2.55	2.60
July	0.96	0.98	0.96	0.96	1.02	1.02	December	2.75	2.78	2.41	2.09	2.18	2.29
August	1.04	1.03	1.11	1.20	1.19	1.27	1865.						
September	1.32	1.28	1.28	1.35	1.39	1.40	January	2.64	3.55	4.12	4.17	4.40	4.46
October	1.40	1.39	1.49	1.68	1.69	1.71	February	4.38	4.31	4.30	4.50	4.70	4.67
November	1.79	1.85	1.85	1.83	1.91	1.98	March	4.50	4.15	3.85	3.27	2.95	2.52
December	2.01	2.01	2.05	1.99	1.85	1.84	April	2.74	2.82	2.67	2.60	2.47	2.27
1863.							May	2.13	2.08	2.10	2.05	2.03	2.08
January	1.90	1.87	1.74	1.70	1.71	1.68	June	2.08	2.04	2.00	2.00	2.07	2.05
February	1.63	1.75	1.82	1.95	2.06	2.15	July	1.91	1.86	1.80	2.03	1.90	1.90
March	2.05	2.12	2.25	2.23	1.97	1.84	August	1.95	1.92	1.86	1.90	1.99	1.98
April	1.86	1.73	1.56	1.47	1.45	1.31	September	2.03	1.99	1.95	1.98	2.00	2.05
May	1.13	1.23	1.47	1.52	1.46	1.59	October	2.08	2.05	2.21	2.41	2.40	2.40

Bi-five day means of the depressions of the water surface, &c.—Continued.

DETROIT, MICHIGAN.

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.	Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1865.							1866.						
November...	2.71	2.70	2.65	2.65	2.65	2.79	December..	2.21	2.25	2.15	2.01	2.03	1.93
December...	2.84	2.87	2.90	2.93	2.75	2.67	1867.						
1866.							January....	1.99	2.62	3.25	3.56	3.84	3.77
January.....	2.17	1.87	2.87	3.66	3.53	3.43	February...	3.45	3.21	3.04	2.75	2.69	3.20
February...	3.43	3.40	3.45	3.53	3.42	3.39	March.....	3.42	3.78	3.90	3.65	3.46	3.13
March.....	3.41	3.33	3.30	3.31	3.39	3.25	April.....	2.50	2.13	2.10	2.15	2.22	2.16
April.....	2.70	2.55	2.54	2.60	2.61	2.59	May.....	2.11	2.11	2.02	1.78	1.65	1.67
May.....	2.46	2.55	2.53	2.52	2.50	2.36	June.....	1.55	1.55	1.50	1.43	1.45	1.51
June.....	2.24	2.25	2.42	2.32	1.98	1.99	July.....	1.62	1.65	1.55	1.51	1.52	1.57
July.....	1.99	1.95	1.95	1.94	2.00	2.12	August.....	1.60	1.65	1.66	1.70	1.83	1.95
August.....	2.12	2.02	2.01	2.09	2.18	2.16	September..	2.04	2.08	2.15	2.14	2.17	2.22
September..	2.13	2.27	2.30	2.25	2.05	2.00	October....	2.32	2.42	2.59	2.59	2.53	2.75
October.....	2.01	2.00	2.00	2.30	2.46	2.35	November..	2.90	2.90	2.80	2.79	3.02	3.07
November...	2.32	2.33	2.32	2.33	2.28	2.21	December..	3.33	3.10	2.66	2.75	2.80	3.52

MONROE, MICHIGAN.

1859.							1860.						
June.....	.....	.....	.....	.....	.....	0.69	December..	2.20	2.07	2.02	1.98	2.02	2.18
July.....	0.51	0.49	0.58	0.72	0.86	0.85	1861.						
August.....	0.79	0.70	0.72	0.88	1.06	1.28	January....	2.31	2.23	2.42	2.55	2.59	2.71
September..	1.36	1.55	1.56	1.32	1.36	1.67	February...	2.73	2.64	2.70	3.00	2.83	2.88
October.....	1.71	1.65	1.98	2.02	1.96	2.09	March.....	2.73	2.25	2.10	2.23	2.06	1.72
November...	2.05	2.24	2.35	1.93	2.14	2.06	April.....	1.26	1.02	1.25	1.23	1.13	0.92
December...	1.79	1.76	1.44	1.55	1.69	1.78	May.....	0.89	0.93	0.77	0.74	0.84	0.77
1860.							June.....	0.65	0.69	0.74	0.71	0.80	0.90
January.....	1.78	1.75	1.83	1.86	2.01	2.02	July.....	0.92	0.93	0.97	1.05	1.15	1.12
February...	2.08	2.18	2.23	2.39	2.33	2.30	August.....	0.92	0.73	0.67	0.85	1.01	1.13
March.....	2.27	2.09	1.99	2.07	2.00	1.85	September.	1.07	1.12	1.12	1.12	1.38	1.39
April.....	1.60	1.46	1.23	1.14	1.22	1.00	October.....	1.17	1.40	1.51	1.42	1.68	1.63
May.....	0.99	0.98	1.13	1.08	0.91	1.03	November..	1.46	1.48	1.46	1.72	1.99	1.81
June.....	1.26	1.26	1.07	1.07	1.12	1.16	December..	1.58	1.59	1.69	1.58	1.58	1.59
July.....	1.14	1.21	1.28	1.37	1.28	1.12	1862.						
August.....	1.15	1.20	1.22	1.25	1.35	1.40	January....	1.67	1.84	1.68	1.61	1.64	1.70
September..	1.40	1.53	1.69	1.95	1.87	1.73	February...	1.85	1.94	1.92	1.99	2.27	2.32
October.....	1.92	2.02	1.83	1.81	1.89	2.05	March.....	2.19	1.86	1.33	1.28	1.15	.....
November...	2.03	2.10	1.94	2.18	2.39	2.34							

CLEVELAND, OHIO.

1859.							1861.						
January.....	.....	.....	.....	.....	.....	.....	April.....	1.53	1.37	1.22	1.16	1.16	1.03
February...	.....	.....	.....	.....	.....	.....	May.....	0.98	0.93	0.82	0.80	0.82	0.79
March.....	.....	.....	.....	.....	.....	.....	June.....	0.76	0.77	0.76	0.80	0.87	0.89
April.....	.....	.....	.....	.....	.....	.....	July.....	0.94	0.96	1.03	1.10	1.17	1.16
May.....	.....	.....	.....	.....	.....	.....	August.....	1.06	0.89	0.87	1.02	1.12	1.11
June.....	0.49	0.45	0.39	0.26	0.40	0.42	September.	1.12	1.24	1.22	1.15	1.22	1.23
July.....	0.51	0.60	0.62	0.68	0.80	0.84	October.....	1.28	1.31	1.36	1.39	1.58	1.46
August.....	0.83	0.79	0.76	0.85	1.00	1.14	November..	1.28	1.34	1.41	1.48	1.64	1.68
September..	1.26	1.34	1.43	1.37	1.32	1.43	December..	1.67	1.65	1.72	1.68	1.62	1.68
October.....	1.39	1.42	1.59	1.65	1.67	1.82	1862.						
November...	1.94	1.99	1.97	1.85	1.92	1.78	January....	1.72	1.75	1.64	1.56	1.67	1.77
December...	1.56	1.72	1.43	1.58	1.64	1.73	February...	1.83	1.94	2.02	2.06	2.06	2.09
1860.							March.....	2.19	2.08	1.80	1.69	1.52	1.34
January.....	1.81	1.81	1.85	1.91	1.98	2.02	April.....	1.10	0.97	1.05	0.87	0.64	0.56
February...	2.08	2.15	2.23	2.29	2.32	2.29	May.....	0.63	0.66	0.65	0.71	0.78	0.79
March.....	2.09	1.84	1.79	1.79	1.79	1.69	June.....	0.68	0.72	0.71	0.66	0.66	0.72
April.....	1.54	1.47	1.28	1.03	0.99	0.99	July.....	0.67	0.65	0.70	0.71	0.78	0.90
May.....	0.99	0.98	0.94	0.91	0.89	0.93	August.....	0.94	0.99	1.09	1.19	1.25	1.22
June.....	0.96	0.92	0.88	0.86	0.96	1.08	September..	1.32	1.36	1.38	1.43	1.51	1.54
July.....	1.11	1.14	1.21	1.24	1.24	1.25	October.....	1.58	1.59	1.69	1.93	2.07	2.15
August.....	1.27	1.26	1.25	1.31	1.38	1.45	November..	2.09	2.10	2.09	1.92	2.19	2.34
September..	1.44	1.51	1.68	1.88	1.93	1.89	December..	2.16	2.20	2.15	2.02	1.98	1.96
October.....	1.95	2.00	1.96	1.99	2.07	2.09	1863.						
November...	2.06	1.98	2.04	2.15	2.20	2.13	January....	1.89	1.73	1.67	1.58	1.42	1.40
December...	2.23	2.26	2.26	2.30	2.23	2.32	February...	1.45	1.40	1.32	1.30	1.33	1.30
1861.							March.....	1.36	1.47	1.45	1.49	1.45	1.40
January.....	2.38	2.32	2.41	2.54	2.68	2.75	April.....	1.43	1.36	1.28	1.21	1.20	1.16
February...	2.74	2.71	2.81	2.89	2.79	2.68	May.....	1.07	1.08	1.15	1.16	1.14	1.19
March.....	2.56	2.42	2.27	2.25	2.21	1.89	June.....	1.22	1.22	1.28	1.30	1.22	1.28

Bi-five day means of the depressions of the water surface, &c.—Continued.

CLEVELAND, OHIO.

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.	Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1863.							1865.						
July	1.30	1.33	1.41	1.42	1.40	1.42	October	2.42	2.46	2.52	2.69	2.66	2.67
August	1.38	1.37	1.40	1.47	1.57	1.67	November	2.88	3.00	2.97	2.87	2.91	3.05
September	1.73	1.78	1.82	1.88	1.99	2.16	December	3.00	2.98	3.03	3.15	3.13	2.98
October	2.18	2.15	2.24	2.32	2.43	2.58	1866.						
November	2.63	2.74	2.76	2.70	2.71	2.80	January	3.00	3.14	3.48	3.52	3.35	3.46
December	2.79	2.73	2.72	2.66	2.67	2.98	February	3.56	3.49	3.50	3.54	3.37	3.30
1864.							March	3.34	3.23	3.05	2.94	2.92	2.80
January	3.16	3.06	3.01	3.00	2.93	2.81	April	2.67	2.65	2.57	2.37	2.30	2.32
February	2.74	2.80	2.94	2.95	2.93	2.89	May	2.33	2.37	2.28	2.27	2.29	2.16
March	2.84	2.69	2.48	2.51	2.58	2.47	June	2.10	2.14	2.08	2.03	1.93	1.84
April	2.40	2.30	2.17	2.06	1.92	1.75	July	1.88	1.97	1.94	1.90	1.95	2.05
May	1.67	1.62	1.44	1.29	1.28	1.31	August	2.11	2.08	2.11	2.20	2.30	2.32
June	1.38	1.47	1.43	1.60	1.63	1.63	September	2.24	2.37	2.40	2.22	2.08	1.99
July	1.67	1.68	1.72	1.80	1.91	1.97	October	2.07	2.25	2.32	2.32	2.41	2.38
August	1.95	2.01	2.06	2.02	2.08	2.15	November	2.49	2.63	2.59	2.39	2.40	2.51
September	2.12	2.17	2.26	2.32	2.38	2.38	December	2.42	2.53	2.49	2.42	2.47	2.59
October	2.40	2.49	2.58	2.68	2.73	2.68	1867.						
November	2.75	2.80	2.66	2.70	2.80	2.73	January	2.63	2.53	2.58	2.76	3.07	3.25
December	2.63	3.72	2.72	2.68	2.68	2.77	February	3.45	3.53	3.19	2.97	2.76	2.63
1865.							March	2.59	2.64	2.61	2.70	2.74	2.83
January	2.82	2.92	3.15	3.16	3.32	3.50	April	2.72	2.54	2.40	2.24	2.17	2.12
February	3.57	3.65	3.76	3.81	3.68	3.54	May	2.05	2.01	1.97	1.84	1.65	1.58
March	3.52	3.50	3.47	3.42	3.17	2.88	June	1.54	1.49	1.49	1.48	1.55	1.67
April	2.82	2.80	2.67	2.58	2.42	2.28	July	1.68	1.67	1.69	1.74	1.78	1.89
May	2.18	2.09	2.00	1.96	2.01	2.03	August	1.88	1.92	2.02	2.08	2.14	2.21
June	2.04	2.03	2.02	2.07	2.16	2.16	September	2.28	2.42	2.37	2.47	2.51	2.55
July	2.12	2.12	2.16	2.12	2.08	2.12	October	2.52	2.61	2.82	2.85	2.85	.....
August	2.18	2.18	2.16	2.16	2.24	2.33	November	.....	.....	.....	.....	.....	.....
September	2.31	2.24	2.16	2.19	2.24	2.27	December	.....	.....	.....	.....	.....	.....

ERIE, PENNSYLVANIA.

1859.							1863.						
June	.....	0.44	0.45	0.46	0.50	0.53	May	.....	.....	.....	.....	.....	.....
July	0.55	0.73	0.72	0.74	0.77	0.96	June	.....	.....	1.22	1.29	1.39	1.46
August	1.10	1.09	1.09	1.18	1.30	1.34	July	1.46	1.57	1.76	1.80	1.75	1.77
September	1.47	1.78	1.65	2.10	2.00	1.99	August	1.70	1.71	1.82	1.92	1.97	2.16
October	1.78	2.05	1.98	1.82	2.24	2.27	September	2.31	2.39	2.34	2.38	2.66	2.75
November	2.33	2.40	2.12	2.41	2.11	1.95	October	2.59	2.83	2.90	2.88	2.96	2.95
December	1.78	2.05	1.98	1.82	2.24	2.27	November	2.81	2.81	2.92	2.95	2.90	2.83
1860.							December	3.03	2.99	2.71	2.93	3 14	3.09
March	.....	.....	.....	.....	.....	.....	1864.						
April	.....	.....	.....	.....	.....	.....	April	2.27	2.08	1.91	1.94	1.85	1.57
May	.....	.....	.....	.....	.....	.....	May	1.44	1.42	1.32	1.26	1.18	1.14
June	.....	.....	.....	.....	.....	.....	June	1.17	1.24	1.31	1.33	1.37	1.39
July	.....	.....	.....	.....	.....	.....	July	1.45	1.60	1.75	1.80	1.84	1.95
August	.....	.....	.....	1.06	1.12	1.24	August	1.96	1.98	2.16	2.17	2.10	2.35
September	1.36	1.49	1.41	1.36	1.43	1.66	September	2.46	2.33	2.35	2.39	2.53	2.73
October	1.70	1.65	1.88	2.01	1.93	1.80	October	2.57	2.45	2.40	2.41	2.51	2.51
November	1.71	1.78	.....	.....	.....	.....	November	2.37	2.15	2.17	2.26	2.37	2.37
December	.....	.....	.....	.....	.....	.....	December	2.18	2.05	2.19	2.32	2.29	2.22
1861.							1865.						
April	1.62	1.40	1.19	1.06	0.96	0.92	April	2.63	2.50	2.36	2.27	2.21	2.16
May	0.84	0.68	0.69	0.75	0.70	0.72	May	2.05	2.01	1.97	1.93	1.92	1.91
June	0.71	0.62	0.66	0.74	0.70	0.65	June	1.93	2.01	1.96	1.85	1.78	1.77
July	0.78	0.84	0.88	0.93	0.96	0.91	July	1.93	1.96	1.91	1.91	1.93	1.98
August	0.91	1.07	1.09	0.96	0 96	1.05	August	1.91	1.91	2.02	2.09	2.17	2.12
September	1.15	1.12	1.13	1.09	1.00	1.14	September	1.98	1.91	1.98	1.97	1.99	1.97
October	1.18	1.06	1.14	1.27	1.31	1.31	October	2.00	2.19	2.25	2.34	2.43	2.43
November	1.29	1.31	1.38	1.43	1.41	1.47	November	2.15	2.11	2.56	2.73	2.63	2.55
December	1.60	1.61	1.52	1.55	1.56	1.51	December	2.64	2.58	2.68	2.44	2.55	.....
1862.							1866.						
April	1.34	1.34	1.16	0.90	0.71	0.65	April	.....	.....	2.40	2.25	2.17	2.19
May	0.58	0.62	0.67	0.68	0.77	0.83	May	2.24	2.26	2.26	2.22	2.08	2.03
June	0.78	0.72	0.71	0.74	0.72	0.67	June	2.00	1.89	1.86	1.82	1.77	1.64
July	0.65	0.63	0.71	0.72	0.71	0.78	July	1.61	1.69	1.68	1.70	1.75	1.70
August	0.88	0.97	1.07	1.20	1.25	1.26	August	1.67	1.72	1.72	1.69	1.82	1.92
September	1.31	1.37	1.48	1.55	1.56	1.51	September	1.93	1.91	2.03	1.90	1.77	1.75
October	1.56	1.65	1.63	1.65	1.78	1.86	October	1.80	1.82	1.87	2.04	2.07	2.07
November	1.92	2.02	2.03	1.94	1.86	1.87	November	2.27	2.26	2.21	2.22	2.18	2.16
December	1.84	1.95	1.88	1.85	2.02	2.02	December	2.12	2.03	.....	.....	.....	.....
1863.							1867.						
April	.....	.....	.....	.....	.....	.....	April	.....	.....	.....	2.07	2.13	2.06

Bi-five day means of the depressions of the water surface, &c.—Continued.

ERIE, PENNSYLVANIA.

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.	Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1867.							1867.						
May	1.92	1.76	1.90	1.75	1.64	1.65	September	2.29	2.16	2.15	2.13	2.27	2
June	1.61	1.72	1.72	1.72	1.74	1.84	October	2.34	2.32	2.55	2.81	2.84	2
July	1.84	1.84	2.01	2.10	2.09	2.12	November	2.27	2.86	2.82	2.94	3.02	2
August	2.30	2.40	2.35	2.20	2.09	2.18	December	2.51	2.91	.....	.....	.....	

BUFFALO, NEW YORK.

1859.							1863.						
June	.....	0.50	0.33	0.34	0.28	0.35	August	1.48	1.40	1.47	1.49	1.51	1
July	0.53	0.56	0.51	0.47	0.56	0.69	September	1.84	1.95	1.94	1.90	1.98	1
August	0.68	0.82	0.97	0.92	0.87	0.89	October	1.82	2.46	2.46	2.39	2.36	2
September	1.19	1.24	1.46	1.74	1.63	1.45	November	2.19	2.21	2.24	2.14	2.10	2
October	1.48	1.54	1.45	1.67	1.83	1.81	December	2.33	2.36	1.95	2.28	.....	
November	1.96	1.88	1.77	1.82	1.92	1.76	1864.						
December	1.57	1.83	.....	.....	.....	.....	April	.....	.....	.....	2.17	2.08	1
1860.							May	1.51	1.64	1.47	1.40	1.39	1
April	1.62	1.33	1.20	1.24	1.21	1.11	June	1.38	1.47	1.61	1.57	1.51	1
May	1.03	1.03	0.90	0.80	0.90	0.91	July	1.64	1.71	1.71	1.77	1.79	1
June	0.84	0.90	1.01	1.14	1.09	1.12	August	1.86	1.94	1.99	1.91	1.87	1
July	1.31	1.18	1.04	0.79	0.80	1.03	September	2.38	2.17	2.06	1.96	2.00	2
August	0.98	1.10	1.24	1.26	1.24	1.31	October	2.26	2.24	2.31	2.34	2.52	2
September	1.52	1.53	1.45	1.38	1.60	1.79	November	2.34	2.22	2.42	2.33	2.26	2
October	1.69	1.69	2.00	2.09	1.96	1.82	December	2.04	.....	.....	.....	.....	
November	1.55	1.60	1.60	1.17	0.90	1.45	1865.						
1861.							May	2.26	2.28	2.34	2.24	2.12	2
April	.....	.....	.....	.....	1.25	1.22	June	2.09	2.25	2.21	2.09	1.86	1
May	1.07	0.83	0.84	0.93	0.87	0.88	July	1.96	2.13	2.17	2.18	2.07	2
June	1.04	0.94	0.85	0.91	0.88	0.92	August	2.16	2.17	2.28	2.32	2.29	2
July	0.98	1.01	1.02	1.05	1.04	1.06	September	2.35	2.44	2.34	2.30	2.29	2
August	1.21	1.39	1.32	1.06	1.04	1.04	October	2.29	2.54	2.53	2.61	2.61	2
September	1.26	1.24	1.25	1.28	1.04	1.05	November	2.35	2.58	2.84	2.94	2.87	2
October	1.26	1.05	1.08	1.25	1.22	1.38	December	2.57	2.53	2.57	.....	.....	
November	1.34	1.21	1.31	1.40	1.23	1.21	1866.						
December	1.41	1.38	1.26	1.47	1.54	1.42	May	.....	.....	2.38	2.37	2.29	2
1862.							June	2.18	2.02	1.98	1.94	1.85	1
April	.....	.....	.....	0.93	0.70	0.71	July	1.85	1.89	1.98	2.01	1.99	1
May	0.57	0.60	0.91	0.90	0.83	0.99	August	1.89	2.12	2.20	2.16	2.19	2
June	0.95	0.84	0.76	0.74	0.73	0.66	September	2.40	2.11	2.28	2.50	2.23	2
July	0.61	0.52	0.66	0 73	0.70	0.77	October	2.17	2.31	2.27	1.89	2.34	2
August	0.77	0.84	1.06	1.17	1.07	1.00	November	2.48	2.51	2.34	2.21	2.14	2
September	1.04	1.13	1.18	1.22	1.39	1.33	December	1.85	1.61	.....	.....	.....	
October	1.27	1.69	1.72	1.18	1.59	1.79	1867.						
November	1.75	1.81	.....	.....	.....	.....	May	.....	.....	1.92	1.74	1.60	1
December	.....	.....	.....	.....	1.83	1.94	June	1.59	1.55	1.45	1.52	1.52	1
1863.							July	1.64	1.54	1.68	1.78	1.66	1
January	1.22	1.44	1.39	.....	.....	.....	August	1.86	1.95	2.09	2.15	2.19	2
April	.....	.....	.....	.....	1.52	1.80	September	2.35	2.36	2.36	2.45	2.60	2
May	1.70	1.40	1.22	1.23	1.44	1.30	October	2.55	2.52	2.60	2.68	2.88	2
June	1.19	1.30	1.36	1.33	1.42	1.51	November	2.36	2.60	2.61	2.81	2.99	2
July	1.48	1.57	1.66	1.60	1.42	1.42	December	2.54	.....	.....	.....	.....	

FORT NIAGARA, NEW YORK.

1859.							1860.						
June	.....	.....	.....	0.08	0.12	0.16	September	1.80	1.88	1.93	1.98	2.05	2
July	0.21	0.28	0.30	0.29	0.32	0.47	October	2.11	2.22	2.33	2.33	2.28	2
August	0.52	0.58	0.60	0.67	0.79	0.96	November	2.23	2.24	2.19	2.11	2.12	2
September	1.12	1.26	1.35	1.38	1.41	1.48	December	2.14	2.13	2.23	2.24	2.29	2
October	1.61	1.72	1.84	1.97	2.10	2.19	1861.						
November	2.28	2.34	2.32	2.26	2.25	2.22	January	2.30	2.35	2.37	2.37	2.36	2
December	2.09	1.99	.....	.....	.....	.....	February	2.38	2.42	2.39	2.32	2.34	2
1860.							March	2.50	2.47	2.46	2.52	2.43	2
January	.....	1.99	2.04	2.08	2.18	2.26	April	2.31	2.32	2.13	1.75	1.43	1
February	2.30	2.35	2.37	2.37	2.38	2.39	May	0.95	0.66	0.55	0.54	0.51	0
March	2.29	2.19	1.86	1.49	1.41	1.41	June	0.36	0.38	0.39	0.38	0.41	0
April	1.65	1.96	1.95	1.94	1.95	1.89	July	0.38	0.38	0.41	0.44	0.47	0
May	1.79	1.79	1.80	1.76	1.69	1.65	August	0.51	0.53	0.60	0.71	0.79	0
June	1.65	1.64	1.64	1.62	1.61	1.61	September	1.01	1.09	1.18	1.21	1.21	1
July	1.56	1.56	1.58	1.54	1.54	1.54	October	1.01	0.91	0.92	0.94	1.02	1
August	1.53	1.58	1.55	1.52	1.59	1.70	November	1.11	1.07	1.13	1.19	1.14	1

Bi-five day means of the depressions of the water surface, &c.—Continued.

FORT NIAGARA, NEW YORK.

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1861.						
December...	1.19	1.23	1.26	1.28	1.29	1.35
1862.						
January.....	1.44	1.53	1.60	1.65	1.71	1.76
February...	1.81	1.86	1.91	1.96	2.01	2.04
March.....	2.07	2.13	2.13	2.16	2.22	2.23
April.....	2.23	2.22	2.22	2.30	2.36	1.53
May.....	0.51	0.25	0.17	0.13	0.14	0.20
June.....	0.27	0.33	0.36	0.38	0.38	0.33
July.....	0.27	0.29	0.39	0.45	0.53	0.61
August.....	0.68	0.76	0.80	0.88	1.01	1.12
September..	1.18	1.24	1.28	1.33	1.43	1.51
October.....	1.54	1.56	1.64	1.77	1.92	2.03
November...	2.05	2.08	2.14	2.25	2.33	2.31
December...	2.28	2.31	2.36	2.38	2.38	2.37
1863.						
January....	2.36	2.38	2.37	2.33	2.30	2.30
February...	2.32	2.33	2.35	2.37	2.38	2.38
March.....	2.38	2.38	2.38	2.36	2.31	2.27
April.....	2.27	2.14	1.90	1.68	1.63	1.62
May.....	1.33	1.04	0.97	0.97	0.89	0.79
June.....	0.74	0.78	0.86	0.87	0.89	0.90
July.....	0.95	1.10	1.19	1.15	1.06	1.05
August.....	1.19	1.34	1.43	1.46	1.48	1.62
September..	1.75	1.88	1.96	2.00	2.06	2.09
October.....	2.09	2.14	2.26	2.35	2.41	2.51
November...	2.57	2.60	2.62	2.63	2.60	2.55
December...	2.53	2.51	2.52	2.50	2.50	2.51
1864.						
January.....	2.53	2.52	2.54	2.56	2.58	2.64
February...	2.76	2.82	2.86	2.91	2.93	2.93
March.....	2.95	2.96	2.97	2.98	2.98	2.99
April.....	3.02	3.04	2.93	2.51	2.15	1.94
May.....	1.66	2.43	2.29	1.22	1.00	0.75
June.....	0.70	0.76	0.81	0.80	0.81	0.87
July.....	1.00	1.02	1.07	1.16	1.38	1.52
August.....	1.57	1.59	1.58	1.59	1.65	1.81
September..	1.93	1.92	1.95	2.02	2.07	2.12
October.....	2.24	2.33	2.33	2.40	2.46	2.44
November...	2.39	2.37	2.36	2.32	2.33	2.32
December...	2.29	2.29	2.32	2.33	2.33	2.32

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1865.						
January.....	2.30	2.30	2.32	2.31	2.31	2.28
February...	2.33	2.34	2.32	2.30	2.31	2.32
March.....	2.32	2.32	2.35	2.41	2.43	2.46
April.....	2.52	2.56	2.58	2.61	2.65	2.71
May.....	2.78	2.76	2.52	2.33	2.32	2.32
June.....	2.23	1.99	1.82	1.80	1.81	1.81
July.....	1.75	1.58	1.48	1.48	1.48	1.51
August.....	1.56	1.56	1.66	1.91	2.04	2.05
September..	2.07	2.08	2.15	2.35	2.50	2.53
October.....	2.54	2.57	2.74	2.83	2.86	2.90
November...	2.93	2.93	2.95	2.97	2.99	3.02
December...	3.06	3.10	3.13	3.13	3.14	3.16
1866.						
January.....	3.20	3.24	3.23	3.25	3.28	3.29
February...	3.32	3.33	3.34	3.34	3.34	3.26
March.....	3.20	3.21	3.22	3.17	3.12	3.00
April.....	2.86	2.76	2.62	2.56	2.51	2.51
May.....	2.45	2.17	2.02	2.13	2.32	2.30
June.....	2.20	1.91	1.81	1.78	1.80	1.80
July.....	1.80	1.82	1.83	1.84	1.84	1.88
August.....	1.95	2.00	2.03	2.05	2.07	2.11
September..	2.14	2.14	2.16	2.18	2.21	2.24
October.....	2.24	2.25	2.15	2.03	2.04	2.03
November...	2.03	2.03	2.01	2.00	2.02	2.03
December...	2.04	1.97	1.89	1.85	1.85	1.83
1867.						
January.....	1.82	1.80	1.79	1.80	1.81	1.80
February...	1.80	1.80	1.79	1.81	1.80	1.82
March.....	1.83	1.83	1.83	1.84	1.85	1.87
April.....	1.87	1.90	1.93	1.97	1.99	2.01
May.....	2.05	2.12	2.01	1.57	0.80	0.50
June.....	2.41	0.41	0.41	0.42	0.46	0.54
July.....	0.60	0.62	0.62	0.63	0.62	0.60
August.....	0.58	0.50	0.38	0.34	0.41	0.53
September..	0.69	0.80	0.90	1.00	1.04	.....
October.....	.....	.....	.....	.....	.....	.....
November...	.....	.....	.....	.....	.....	.....
December...	.....	.....	.....	.....	.....	.....

CHARLOTTE, NEW YORK.

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1859.						
June.....	.....	.....	.....	0.16	0.21	0.23
July.....	0.28	0.38	0.41	0.43	0.49	0.56
August.....	0.58	0.66	0.78	0.91	1.01	1.07
September..	1.22	1.34	1.45	1.53	1.53	1.58
October.....	1.64	1.76	1.85	1.92	2.08	2.24
November...	2.37	2.42	2.49	2.32	2.28	2.22
December...	2.11	2.01	2.00	2.02	2.00	2.08
1860.						
January.....	2.19	2.15	2.10	2.13	2.13	2.19
February...	2.26	2.30	2.34	2.35	2.34	2.31
March.....	2.25	2.18	2.18	2.16	2.14	2.20
April.....	2.19	2.18	2.17	2.13	2.10	2.11
May.....	2.08	2.02	1.96	1.92	1.89	1.82
June.....	1.74	1.72	1.72	1.73	1.74	1.74
July.....	1.72	1.69	1.64	1.57	1.57	1.61
August.....	1.62	1.63	1.76	1.90	1.91	1.97
September..	2.08	2.16	2.23	2.28	2.32	2.36
October.....	2.42	2.46	2.40	2.36	2.36	2.34
November...	2.28	2.19	2.18	2.18	2.24	2.16
December...	2.15	2.20	2.26	2.25	2.23	2.32
1861.						
January.....	2.37	2.42	2.44	2.44	2.49	2.58
February...	2.65	2.56	2.37	2.23	2.27	2.22
March.....	2.02	1.97	1.96	2.00	1.97	1.81
April.....	1.69	1.59	1.45	1.32	1.21	1.04
May.....	0.88	0.74	0.62	0.59	0.54	0.49
June.....	0.47	0.43	0.41	0.40	0.45	0.44
July.....	0.40	0.39	0.40	0.43	0.48	0.50

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1861.						
August.....	0.54	0.66	0.74	0.78	0.86	0.95
September..	1.08	1.18	1.23	1.29	1.19	1.07
October.....	0.99	0.95	0.97	1.02	1.10	1.13
November..	1.06	1.04	1.09	1.16	1.21	1.21
December..	1.26	1.28	1.29	1.34	1.40	1.48
1862.						
January.....	1.59	1.66	1.67	1.73	1.78	1.81
February...	1.83	1.88	1.97	2.03	2.03	2.07
March.....	2.10	1.98	1.74	1.62	1.66	1.57
April.....	1.33	1.21	1.08	0.74	0.51	0.36
May.....	0.25	0.12	0.10	0.09	0.10	0.14
June.....	0.24	0.29	0.30	0.32	0.33	0.36
July.....	0.37	0.40	0.43	0.42	0.40	0.43
August.....	0.52	0.60	0.73	0.84	0.92	1.00
September..	1.05	1.14	1.26	1.34	1.44	1.54
October.....	1.59	1.67	1.76	1.83	1.90	1.95
November...	1.99	2.05	2.19	2.24	2.19	2.22
December...	2.27	2.33	2.28	2.25	2.27	2.25
1863.						
January.....	2.28	2.28	2.20	2.17	2.14	2.10
February...	2.07	1.99	2.00	2.00	1.96	1.91
March.....	1.88	1.86	1.87	1.92	1.79	1.63
April.....	1.60	1.49	1.25	1.00	0.89	0.85
May.....	0.83	0.79	0.72	0.68	0.69	0.71
June.....	0.68	0.69	0.76	0.78	0.82	0.89
July.....	0.91	0.93	0.98	1.04	1.09	1.12
August.....	1.15	1.20	1.26	1.36	1.46	1.58
September..	1.72	1.83	1.86	1.87	1.97	2.08

Bi-five day means of the depressions of the water surface, &c.—Continued.

CHARLOTTE, NEW YORK.

Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.	Date.	1st to 10th.	6th to 15th.	11th to 20th.	16th to 25th.	21st to 30th.	26th to 5th.
1863.							1865.						
October	2.13	2.21	2.29	2.31	2.39	2.51	November	2.90	2.96	3.07	3.07	3.03	3.04
November	2.51	2.54	2.53	2.42	2.38	2.38	December	3.03	3.04	3.07	3.10	3.14	3.12
December	2.42	2.48	2.44	2.42	2.52	2.56	1866.						
1864.							January	3.14	3.24	3.31	3.32	3.34	3.40
January	2.65	2.65	2.65	2.75	2.62	2.64	February	3.48	3.51	3.53	3.55	3.49	3.34
February	2.56	2.55	2.61	2.70	2.74	2.70	March	3.30	3.31	3.23	3.08	3.04	3.06
March	2.69	2.57	2.45	2.50	2.56	2.51	April	3.02	2.93	2.88	2.78	2.60	2.50
April	2.38	2.18	1.98	1.87	1.72	1.54	May	2.48	2.43	2.38	2.34	2.28	2.21
May	1.42	1.19	0.88	0.75	0.67	0.57	June	2.09	2.02	1.95	1.88	1.87	1.88
June	0.56	0.57	0.63	0.70	0.76	0.80	July	1.86	1.84	1.85	1.86	1.88	1.88
July	0.86	0.93	1.05	1.15	1.21	1.25	August	1.90	1.97	2.04	2.06	2.14	2.23
August	1.30	1.37	1.45	1.54	1.53	1.58	September	2.24	2.21	2.21	2.24	2.24	2.24
September	1.77	1.92	1.99	2.06	2.13	2.17	October	2.25	2.28	2.33	2.40	2.45	2.43
October	2.15	2.17	2.26	2.35	2.34	2.25	November	2.43	2.50	2.39	2.23	2.18	2.11
November	2.20	2.12	2.08	2.16	2.19	2.09	December	1.99	1.90	1.85	1.82	1.78	1.80
December	1.97	1.89	1.91	1.93	1.92	2.01	1867.						
1865.							January	1.86	1.85	1.92	1.99	2.02	2.06
January	2.08	2.12	2.16	2.26	2.36	2.43	February	2.04	2.02	1.96	1.87	1.86	1.83
February	2.47	2.48	2.53	2.62	2.65	2.62	March	1.82	1.81	1.81	1.84	1.84	1.81
March	2.60	2.54	2.19	1.79	1.68	1.61	April	1.63	1.46	1.37	1.29	1.21	1.11
April	1.55	1.52	1.50	1.48	1.47	1.45	May	0.95	0.79	0.67	0.59	0.48	0.38
May	1.36	1.29	1.24	1.17	1.15	1.19	June	0.32	0.30	0.28	0.30	0.36	0.32
June	1.22	1.23	1.28	1.32	1.33	1.33	July	0.42	0.49	0.56	0.64	0.72	0.79
July	1.35	1.40	1.49	1.56	1.59	1.68	August	0.71	0.53	.....	.....	.....	.....
August	1.77	1.79	1.90	2.00	2.13	2.25	September	.....	.....	.....	.....	.....	.....
September	2.32	2.31	2.30	2.32	2.37	2.43	October	.....	.....	.....	.....	.....	.....
October	2.52	2.59	2.64	2.69	2.77	2.85							

SACKETT'S HARBOR, NEW YORK.

1859.							1861.						
June	.....	.....	.....	.....	0.27	0.32	January	2.46	2.74	2.67	2.66	2.69	2.65
July	0.40	0.49	0.51	0.49	0.47	0.51	February	2.64	2.66	2.70	2.69	2.66	.....
August	0.56	0.61	0.74	0.83	0.87	0.88	March	2.72	2.76	2.77	2.79	2.74	2.49
September	1.03	1.07	1.25	1.51	1.53	1.52	April	2.12	1.95	1.82	1.64	1.52	1.39
October	1.57	1.70	1.74	1.83	2.04	2.19	May	1.20	1.00	0.90	0.75	0.63	0.61
November	2.35	2.39	2.38	2.40	2.32	2.34	June	0.62	0.56	0.52	0.53	0.55	0.59
1860.							July	0.57	0.50	0.50	0.53	0.57	0.62
March	.....	.....	.....	2.12	2.03	2.11	August	0.65	0.78	.....	.....	.....	.....
April	2.19	2.17	2.14	2.11	2.06	2.01	September	.....	.....	.....	.....	.....	.....
May	2.03	1.97	1.83	1.83	1.85	1.76	October	.....	.....	.....	1.01	1.16	1.30
June	1.66	1.64	1.64	1.65	1.68	1.65	November	1.37	1.35	1.43	1.54	1.53	1.43
July	1.63	1.62	1.57	1.53	1.59	1.63	December	1.42	1.43	1.36	1.31	1.48	1.52
August	1.66	1.71	1.78	1.76	1.73	1.73	1862.						
September	1.87	2.05	2.14	2.12	2.13	2.27	January	1.52	1.49	1.49	.....	.....	.....
October	2.42	2.43	2.51	2.65	2.61	2.56	March	.....	1.51	1.45	1.41	1.38	1.33
November	2.54	2.47	2.39	2.18	2.16	2.38	April	1.31	1.27	1.22	.....	.....	.....
December	2.50	2.61	2.68	2.68	.....	2.42							

The means for all the stations on each lake were separately plotted and a mean curve was drawn with a free hand. These curves for the different lakes and Detroit river are given in the accompanying plate.

In the report for 1860 I gave the curves of the several lakes and Detroit river for the 10 years previous; this was mostly compiled from old notes at different places.

In the present plate I duplicate the last year on the former, and continue it to the present time. I also give the curve of the monthly rain-fall in a dotted line on the same plate. In the following table I have also placed in consecutive columns the mean yearly stage of water below the high water of 1838, and the yearly rain-fall:

Mean yearly stage of water below the high water of 1838, *and the yearly rain-fall.*

	Lake Superior.	Lake Michigan.	Lake Huron.	Detroit river.	Lake Erie.	Lake Ontario.	Means.
1859.—Mean level of water.....feet.	.....	.....	1.24	.....	.....	.....	.....
Yearly rain-fall.....inches.	.....	.....	27.90	.....	.....	.....	.....
1860.—Mean level of water.....feet.	.....	2.00	1.57	.....	1.66	2.04	1.82
Yearly rain-fall.....inches.	24.31	26.84	21.78	28.03	31.29	29.39	26.94
1861.—Mean level of water.....feet.	.....	1.85	1.62	1.66	1.50	1.34	1.59
Yearly rain-fall.....inches.	36.13	28.47	28.34	38.40	35.58	37.52	34.07
1862.—Mean level of water.....feet.	.....	1.93	1.64	1.59	1.38	1.34	1.58
Yearly rain-fall.....inches.	28.72	30.52	30.83	31.44	36.58	27.91	31.00
1863.—Mean level of water.....feet.	.....	2.41	2.15	1.79	1.78	1.65	1.96
Yearly rain-fall.....inches.	24.59	32.40	31.14	30.37	31.69	29.55	29.96
1864.—Mean level of water.....feet.	.....	3.18	2.57	2.12	2.27	1.94	2.42
Yearly rain-fall.....inches.	21.79	27.71	25.47	25.88	34.00	33.77	28.10
1865.—Mean level of water.....feet.	.....	2.21	.....	2.68	2.61	2.14	2.66
Yearly rain-fall.....inches.	27.65	30.68	29.33	21.10	32.67	28.89	28.29
1866.—Mean level of water.....feet.	.....	3.55	.....	2.49	2.46	2.45	2.74
Yearly rain-fall.....inches.	26.82	32.29	19.56	31.72	38.15	33.88	30.60
1867.—Mean level of water.....feet.	.....	3.23	.....	2.38	2.43	1.26	2.32
Yearly rain-fall.....inches.	23.99	24.62	20.20	26.87	28.61	23.41	24.62
Means.—Mean level of water....feet.	.....	2.67	1.80	2.10	2.01	1.77	2.14
Yearly rain-fall.....inches.	26.75	29.12	26.06	29.23	33.70	30.54	29.23

A careful study of the curves and of the amounts in the above table will show that the fluctuations of the water level cannot be entirely accounted for by the difference in the amount of rain-fall. In Lake Michigan, for instance, from the table it will be seen that the amount of rain-fall for the years 1860 and 1861 was below the average, while the water was quite high; in 1862 and 1863 the rain-fall was above average and the water falling rapidly, and so on.

In Lake Ontario, in 1861, the water rose apparently in accordance with the large amount of rain during the year, while in 1862 the mean level of the water was the same, while the rain-fall was nearly 10 inches less. These differences would seem to show that there is some means by which water reaches the lakes besides that drained from the water-shed. As from the numerous artesian wells which have been sunk within the past few years it is plainly shown that there are large bodies of water and even rivers beneath the surface, and as the lakes form deep depressions (the bottom of Lake Superior is about 400 feet below the sea level) with which these subterranean reservoirs may communicate, it is not improbable that they may bring to the lakes the water from regions far beyond the boundary line of their limited drainage. For the basin of the lakes is small compared with their surface, the line between the water-shed of the Mississippi river and its tributaries and that of the lakes is not more than five or ten miles from the latter, and the amount of water which flows out of them is much more than the inflow from the surface drainage, as I have shown in my report on the measurements for the determination of the outflow of the lakes.

The following table shows the time of high and low water in the several lakes and Detroit river:

Year.	Lake Michigan.		Lake Huron.		Detroit river.		Lake Erie.		Lake Ontario.	
	High water.	Low water.	High water.	Low water.	High water.	Low water.	High water.	Low water.	High water.	Low water.
1859	.....	Dec. 30	July 20	Jan. 5	.....	.....	June 20	Nov. 15	.....	Nov. 15
1860	July 10	Dec. 30	July 20	Dec. 30	.....	.....	May 25	Feb. 20	July 30	Feb. 20
1861	Aug. 10	Jan. 25	Aug. 5	Jan. 18	Aug. 15	Feb. 10	June 15	Feb. 20	June 25	Feb. 5
1862	Aug. 25	Feb. 10	Oct. 10	Mar. 25	April 30	Feb. 25	May 5	Mar. 5	May 25	Dec. 15
1863	June 25	Dec. 30	June 5	Dec. 30	May 5	Dec. 15	May 20	Dec. 30	June 5	Nov. 15
1864	June 15	Dec. 30	June 5	Feb. 1	June 15	Mar. 20	May 25	Jan. 10	June 5	Mar. 1
1865	May 25	Dec. 30	.....	.....	July 15	Feb. 25	July 1	Feb. 20	June 1	Dec. 30
1866	May 5	Jan. 1	.....	.....	Jan. 10 July 20	Jan. 20	July 10	Feb. 10	July 5 Dec. 30	Feb. 15
1867	July 5	Jan. 1	.....	.....	June 20	Mar. 15	June 15	Feb. 15	June 15	Feb. 1

From this it will be seen that there is no regular time for high or low water, but that it can only be said that the former is generally in summer and the latter in winter.

The water in the Detroit river is more affected by the direction of the wind than at any other place, for, on account of the sudden bend in the river, a southwest wind will blow the water out of both ends of the river, and a northeast wind will bring down the water from Lake St. Clair and back it up at Lake Erie. This is shown in 1866 in the table, the highest and lowest stage of the water occuring in the month of January; in that month, there having been first a strong southwest and then a strong northeast wind, making the difference of the highest and lowest level of the water over three feet.

In Lake Ontario during this year the water, after reaching the summer maximum in July, fell slightly and then rose again to the close of the year. This is an anomaly not easily accounted for, for the rain-fall of the year on that lake is not much above the average, and it is pretty equally distributed through the seasons.

At Buffalo, however, the autumn rain is nearly one-half the amount for the year, and at Cleveland, in the month of June, nearly 11 inches fell; the autumn amount being also quite large; this may have passed into Lake Ontario, raising it without much affecting Lake Erie. This supposition seems, however, rather more improbable than that of a subterranean inflow. But all of these speculations only show how little we really know of the reasons of the fluctuations in the lakes, and which can only be found out by more extended series of observations.

I inclose the following table and explanation, compiled by Mr. J. H. Lapham, LL.D., the observer at Milwaukee, Wisconsin. The temperature curves are also given on the accompanying plate.

The study of these are very interesting, and I hope that Mr. Lapham may be induced to make further contributions of this nature.

I remain, very respectfully, your obedient servant,

D. FARRAND HENRY,
Assistant Lake Survey.

Brevet Brigadier General W. F. RAYNOLDS,
In charge Lake Survey.

MILWAUKEE, *January* 10, 1868.

DEAR SIR: I have, with much labor, carefully ascertained the mean mperature of every day in the year at this place from all the observaons up to December 31, 1867, covering 24 to 27 years. These have en reduced to equivalent hourly observations by the use of the Toronto bles. As the resulting curve still has numerous short, irregular fluctations, a mean curve has been found by construction.

This, when compared with what may be called the normal curve of mperature, (curve of the sines,) shows the effects of extraneous or cal causes, and brings out some interesting facts, which I presume will of interest to the lake survey. I therefore send you a rough profile, ith the figures upon which it is based.

You will notice that it shows—

1st. An unexplained elevation of temperature about March 1.
2d. The "little winter" in April.
3d. A depression in May and June.
4th. An elevation in August, September, and October, due to the fluence of the waters of Lake Michigan.
5th. The "Indian summer" is shown by a swell in the curve for ovember.

Very truly yours,

I. A. LAPHAM.

General W. F. RAYNOLDS,
In charge Lake Survey.

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ble showing the normal and mean temperatures corrected for hourly observations for every five days. Compiled by I. A. Lapham, from observations made during 26 years ending December 31, 1867, at Milwaukee, Wisconsin.

Date.	Temperature.			Date.	Temperature.			Date.	Temperature.		
	Normal.	Mean.	Diff.		Normal.	Mean.	Diff.		Normal.	Mean.	Diff.
	°	°			°	°			°	°	
n. 17	21.0	21.0	0.0	May 20	58.1	54.1	+4.0	Sept. 20	56.6	59.8	−3.2
20	21.0	21.1	−0.1	25	59.8	55.6	+4.2	25	54.7	57.6	−2.9
25	21.2	21.6	−0.4	31	61.7	57.6	+4.1	30	52.7	55.6	−2.9
31	21.7	22.0	−0.3	June 5	63.2	60.7	+2.5	Oct. 5	50.8	55.3	−2.7
b. 5	22.2	22.8	−0.6	10	64.7	62.2	+2.5	10	48.6	51.5	−2.9
10	23.0	23.6	−0.6	15	65.9	64.1	+1.8	15	46.6	49.0	−2.4
15	23.9	24.8	−0.9	20	66.9	66.1	+0.8	20	45.4	46.5	−1.1
20	25.1	26.3	−1.2	25	67.8	67.9	−0.1	25	42.2	44.5	−2.3
25	26.4	27.8	−1.4	30	68.6	68.6	0.0	31	39.8	43.0	−3.2
28¼	27.1	28.7	−1.6	July 5	69.1	68.8	+0.3	Nov. 5	37.8	41.3	−3.5
ar. 5	28.6	29.8	−1.2	10	69.6	69.3	+0.3	10	35.9	39.3	−3.4
10	30.3	31.1	−0.8	15	69.7	69.6	+0.1	15	33.8	37.2	−3.4
15	32.0	32.4	−0.4	18	69.8	69.8	0.0	20	32.2	35.0	−2.8
20	33.7	33.7	−0.0	20	69.8	69.7	+0.1	25	30.5	32.7	−2.2
25	35.6	35.7	−0.1	25	69.6	69.3	+0.3	30	28.8	30.8	−2.0
31	38.0	38.0	−0.0	31	69.3	69.0	+0.3	Dec. 5	27.4	28.6	−1.2
pril 5	40.0	39.3	+0.7	Aug. 5	68.6	69.0	−0.4	10	26.1	26.7	−0.6
10	42.0	41.5	+0.5	10	68.1	68.6	−0.5	15	24.9	25.3	−0.4
15	44.2	43.1	+1.1	15	67.1	68.3	−1.2	20	23.7	24.3	−0.6
20	46.1	44.6	+1.5	20	66.1	67.8	−1.7	25	23.0	23.4	−0.4
25	48.3	45.9	+2.4	25	64.9	66.8	−1.9	31	22.0	22.4	−0.4
30	50.3	47.0	+3.3	31	63.2	65.9	−2.7	Jan. 5	21.5	22.2	−0.7
ay 5	52.5	49.0	+3.5	Sept. 5	61.7	64.8	−3.1	10	21.1	21.5	−0.4
10	54.4	50.6	+3.8	10	60.0	63.5	−3.5	15	21.0	21.1	−0.1
15	56.4	52.5	+3.9	15	58.3	61.8	−3.5	17	21.0	21.0	0.0

= annual mean temperature = 45°.4 Fahr.

= radius or ½ the mean range = $\frac{69°.8 - 21°}{2}$ = 24°.4.

. Day = $\frac{360°}{365.25}$ = 0°98563 = 59′138.

= A + R. Sin χ.
; quad. Y = A + R sin χ − 90°.
quad. Y = A + R cos χ − 180°.

3d quad. Y = A − R sin χ − 270°.
4th quad. Y = A − R cos χ.
Min., January 17.
Means, April 24 and October 22.
Max., July 18.
Above the mean, April 24 — October 22 = 181 days.
Below the mean, October 22 — April 24 = 184¼ days.
From January 17 to July 18 = 182¼ days.
From July 18 to January 17 = 183 days.

SUPERIOR CITY, WISCONSIN.—ALTITUDE 640 FEET.

Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	1.994	0.547	1.273	1.708	0.620	1.289	1.736	0.567	1.241	1.793	0.400	1.222	1.486	0.525	1.163	1.597	0.710	1.244
1861	1.884	0.773	1.336	1.668	0.513	1.192	1.940	0.650	1.295	1.586	0.657	1.182	1.762	0.259	1.237	1.535	0.903	1.262
1862	1.834	0.972	1.418	1.717	0.748	1.351	1.630	0.723	1.283	1.738	0.831	1.376	1.698	0.994	1.331	1.671	0.910	1.336
1863	1.710	0.592	1.266	1.916	0.547	1.423	1.781	0.825	1.335	1.769	0.618	1.351	1.638	0.858	1.301	1.753	0.988	1.304
1864	1.794	0.634	1.279	1.802	0.793	1.205	1.720	0.709	1.225	1.705	1.114	1.362	1.503	0.728	1.244	1.600	0.864	1.331
1865	1.689	0.952	1.350	1.869	0.787	1.386	1.709	0.695	1.280	1.878	0.245	1.269	1.523	0.741	1.261	1.537	0.841	1.239
1866	2.371	1.012	1.479	1.845	0.640	1.396	2.018	0.706	1.464	1.750	0.614	1.251	1.624	0.751	1.261	1.653	0.685	1.172
1867	1.878	0.843	1.361	1.839	0.594	1.295	1.764	0.817	1.412	1.534	0.725	1.222	1.616	0.892	1.279	1.464	0.840	1.202

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859				1.613	0.991	1.291	1.742	0.753	1.314	1.725	0.780	1.356	1.852	0.525	1.307	2.003	0.825	1.396
1860	1.680	0.692	1.240	1.528	0.958	1.276	1.816	0.680	1.343	1.852	0.859	1.359	1.684	0.463	1.255	1.832	0.820	1.408
1861	1.578	0.965	1.247	1.600	1.075	1.363	1.839	0.718	1.313	1.640	0.632	1.223	1.730	0.613	1.220	1.983	0.880	1.398
1862	1.555	0.867	1.231	1.614	0.855	1.291	1.734	0.873	1.299	2.026	0.671	1.270	2.004	0.829	1.388	2.019	0.740	1.312
1863	1.634	1.043	1.315	1.542	0.930	1.298	1.773	0.961	1.335	1.973	0.388	1.340	1.911	0.651	1.274	1.824	0.755	1.424
1864	1.765	1.120	1.317	1.622	0.810	1.266	1.512	0.776	1.261	1.739	0.822	1.280	1.759	0.529	1.243	1.856	0.511	1.244
1865	1.703	0.928	1.352	1.599	0.973	1.345	1.711	0.878	1.273	1.745	0.857	1.388	1.880	0.572	1.279	1.888	0.393	1.281
1866	1.754	0.914	1.254	1.650	0.891	1.332	1.637	0.881	1.298	1.817	0.692	1.318	2.001	0.770	1.294	1.811	0.605	1.313
1867	1.522	0.860	1.239	1.589	1.015	1.283	1.711	0.674	1.320	1.692	0.739	1.341	1.623	0.393	1.224	1.894	0.447	1.304

SUPERIOR CITY, WISCONSIN. + 28 INCHES.

Year.	Maximum, minimum, and mean barometrical pressure reduced to 32° Fahrenheit for seasons.															
	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							1.852	0.525	1.325				(1.852)	(0.525)		(1.327)
1860	1.793	0.400	1.208	1.680	0.692	1.253	1.852	0.463	1.319	2.003	0.547	1.319	1.944	0.400	1.276	1.544
1861	1.940	0.259	1.238	1.600	0.903	1.291	1.839	0.613	1.259	1.884	0.513	1.312	1.983	0.259	1.274	1.724
1862	1.738	0.723	1.330	1.671	0.855	1.286	2.026	0.671	1.319	1.983	0.748	1.389	2.026	0.671	1.324	1.355
1863	1.781	0.618	1.329	1.753	0.930	1.305	1.973	0.388	1.316	2.019	0.547	1.334	1.973	0.388	1.322	1.585
1864	1.720	0.709	1.377	1.765	0.810	1.305	1.759	0.529	1.261	1.824	0.634	1.303	1.856	0.541	1.288	1.315
1865	1.878	0.245	1.270	1.703	0.878	1.312	1.880	0.572	1.313	1.869	0.541	1.327	1.880	0.393	1.308	1.487
1866	2.018	0.614	1.325	1.754	0.685	1.253	2.001	0.692	1.303	2.371	0.393	1.385	2.371	0.605	1.318	1.766
1867	1.764	0.725	1.311	1.589	0.840	1.241	1.711	0.393	1.295	1.878	0.594	1.323	1.878	0.393	1.292	1.485

SUPERIOR CITY, WISCONSIN.

Year.	Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.																	
	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	49	—32	12.6	49	—21	15.3	69	11	34.2	68	17	37.7	71	18	47.9	76	46	57.5
1861	32	—21	13.3	46	—33	17.2	50	—15	29.9	61	18	36.6	78	23	43.4	82	31	53.7
1862	32	—31	9.2	36	—30	7.0	43	—11	22.9	61	3	34.0	82	25	46.9	89	38	54.9
1863	45	—17	18.9	47	—38	13.6	50	—10	23.4	67	15	38.6	90	24	51.4	94	29	57.6
1864	53	—37	13.7	55	—33	19.6	59	—17	23.3	58	18	36.0	92	24	48.7	96	32	57.9
1865	42	—26	11.2	42	—12	19.5	61	—21	21.6	70	—5	35.0	92	23	47.[illegible]	90	37	54.4
1866	45	—23	10.5	47	—31	9.1	50	—13	17.3	62	10	36.0	83	20	46.3	92	32	57.6
1867	30	—24	7.8	40	—27	12.9	60	—24	15.2	68	16	39.0	61	15	42.1	82	41	57.6

SUPERIOR CITY, WISCONSIN.

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859				81	43	63.7	71	21	52.9	81	21	41.4	45	10	29.6	29	—31	4.2
1860	88	44	65.3	83	47	60.6	78	32	52.3	69	23	43.6	50	—11	28.0	38	—19	14.8
1861	87	35	60.2	86	39	61.8	82	25	55.8	75	21	43.9	55	—15	30.1	41	—14	19.7
1862	90	45	64.5	89	45	64.7	83	35	55.5	68	18	43.1	54	— 3	27.4	45	—18	21.1
1863	84	36	62.0	87	33	61.7	86	24	53.0	72	16	38.6	59	—13	28.7	47	—28	20.0
1864	94	43	64.2	97	42	68.3	84	27	52.4	65	22	43.2	60	—10	28.8	40	—22	10.5
1865	88	40	61.8	92	42	64.0	88	40	61.8	65	18	44.7	66	16	38.3	38	—28	11.1
1866	99	43	67.6	84	39	61.2	75	23	52.8	84	15	44.8	58	0	31.4	49	—20	14.6
1867	77	48	65.3	77	48	67.4	80	26	53.9	80	20	45.3	64	—19	31.7	33	—23	12.0

SUPERIOR CITY, WISCONSIN.

Maximum, minimum, and mean temperature for seasons and years, from 1859 to 1867, inclusive.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							81	10	41.3							
1860	71	11	39.9	88	44	60.1	78	—11	41.3	49	—32	10.7	88	—32	39.2	120
1861	78	—15	34.0	87	31	58.6	82	—15	43.3	46	—33	15.1	87	—33	38.1	120
1862	82	—11	34.6	90	38	61.4	83	— 3	42.0	41	—31	12.0	90	—31	37.6	121
1863	90	—10	37.8	94	29	60.4	86	—13	40.1	47	—38	17.9	94	—38	39.0	132
1864	92	—17	36.0	97	32	63.5	84	—10	41.5	55	—37	17.8	97	—37	38.8	134
1865	92	—21	34.8	92	37	60.1	88	16	48.3	42	—26	13.7	92	—26	39.3	120
1866	83	—13	35.2	99	32	62.1	84	0	43.0	47	—31	10.2	99	—31	37.4	130
1867	68	—24	32.1	82	41	63.4	80	—19	43.3	49	—27	11.8	82	—27	37.4	109

SUPERIOR CITY, WISCONSIN.

Year.	Amount of rain and melted snow for months, seasons, and years, in United States inches and decimals.															
	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859								0.96	2.24	1.42	2.05	0.38			5.71		
1860	1.35	1.90	1.19	1.19	5.57	1.14	2.06	5.52	2.74	3.47	0.50	0.42	7.95	8.72	6.71	3.63	27.05
1861	1.40	4.24	1.33	3.83	4.57	3.59	2.54	3.09	5.18	3.74	2.35	0.49	9.73	9.22	11.27	6.06	36.35
1862	1.29	0.87	1.67	1.93	0.98	2.26	2.47	2.56	5.13	2.08	0.46	0.80	4.58	7156	7.67	2.65	22.77
1863	0.63	0.83	0.43	0.42	2.27	0.42	1.86	4.84	1.36	2.73	0.14	1.37	3.12	7.12	4.23	2.26	17.30
1864	0.46	0.78	2.01	0.72	1.24	1.46	3.64	3.58	2.49	1.91	1.84	0.84	3.97	8.68	6.24	2.61	20.97
1865	0.34	2.30	1.24	3.31	2.31	4.57	4.06	3.07	6.22	0.82	0.59	1.23	6.86	11.70	7.63	3.48	30.06
1866	0.93	0.18	2.23	2.78	1.23	2.96	4.47	1.31	4.08	2.45	2.52	0.60	8.24	8.74	9.05	2.34	25.74
1867	0.29	1.51	0.34	1.49	2.05	8.24	6.15	1.41	3.80	1.16	0.22	1.41	3.88	15.80	5.18	2.40	28.07

ONTONAGON, MICHIGAN.—ALTITUDE 610 FEET.

Year.	Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.																	
	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	1.893	0.579	1.303	1.761	0.444	1.299	1.757	0.591	1.328	1.839	0.492	1.321	1.514	0.627	1.209	1.680	0.412	1.282
1861	1.854	0.715	1.318	1.730	0.527	1.224	1.929	0.502	1.325	1.655	0.739	1.235	1.897	0.214	1.263	1.602	0.726	1.268
1862	1.819	1.030	1.378	1.699	0.747	1.352	1.632	0.602	1.271	1.733	0.997	1.398	1.722	1.035	1.331	1.627	0.949	1.337
1863	1.787	0.742	1.213	1.946	0.567	1.438	1.878	0.824	1.363	1.775	0.692	1.358	1.593	0.816	1.316	1.752	0.742	1.309
1864	1.775	0.582	1.245	1.719	0.652	1.161	1.668	0.711	1.192	1.690	1.078	1.344	1.610	0.728	1.233	1.789	0.841	1.380
1865	1.710	0.359	1.252	1.794	0.817	1.375	1.677	0.639	1.238	1.807	0.311	1.261	1.506	0.688	1.249	1.534	0.825	1.218
1866	2.430	0.915	1.445	1.808	0.603	1.406	1.919	0.635	1.461	1.720	0.666	1.282	1.653	0.755	1.271	1.673	0.775	1.194
1867	1.842	0.781	1.332	1.866	0.630	1.485	1.782	0.824	1.418	1.585	0.814	1.242	1.607	0.835	1.285	1.487	0.791	1.205

ONTONAGON, MICHIGAN.—ALTITUDE 610 FEET.

Maximum, minimum, and mean barometrical pressure for each month, from 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	.....	.....	.....	1.785	1.030	1.308	1.760	0.812	1.356	1.775	0.967	1.367	1.991	0.685	1.407	1.708	0.856	1.339
1860	1.689	0.648	1.257	1.582	1.927	1.298	1.840	0.747	1.363	1.827	0.845	1.365	1.663	0.385	1.218	1.923	0.781	1.383
1861	1.576	1.013	1.273	1.635	1.059	1.367	1.804	0.667	1.320	1.666	0.633	1.221	1.753	0.542	1.207	1.862	0.745	1.370
1862	1.542	0.884	1.237	1.601	1.892	1.307	1.766	0.832	1.329	1.963	0.708	1.276	2.043	0.888	1.389	2.017	0.790	1.279
1863	1.634	1.024	1.316	1.569	1.987	1.315	1.794	0.977	1.370	1.937	0.442	1.346	1.871	0.673	1.262	1.857	0.605	1.401
1864	1.747	1.032	1.355	1.575	1.772	1.275	1.579	0.767	1.275	1.694	0.314	1.227	1.764	0.567	1.220	1.790	0.452	1.124
1865	1.636	0.905	1.318	1.539	1.986	1.330	1.650	0.976	1.256	1.762	0.735	1.370	1.942	0.439	1.257	1.748	0.389	1.205
1866	1.643	0.943	1.264	1.732	1.969	1.347	1.652	0.781	1.325	1.891	0.565	1.353	2.054	0.793	1.309	1.951	0.637	1.320
1867	1.497	0.894	1.253	1.586	1.892	1.296	1.720	0.791	1.337	1.773	0.570	1.350	1.667	0.461	1.249	1.870	0.320	1.288

ONTONAGON, MICHIGAN. + 28 INCHES.

Maximum, minimum, and mean barometrical pressure reduced to 32° Fahr.—for seasons.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859	.....	.....	.....	.....	.....	.....	1.991	0.685	1.376	.....	.....	.....	1.991	0.685	.....	1.306
1860	1.859	0.492	1.286	1.689	0.412	1.279	1.840	0.385	1.315	1.893	0.444	1.314	1.923	0.385	1.302	1.538
1861	1.929	0.214	1.274	1.635	0.726	1.302	1.804	0.542	1.249	1.923	0.527	1.308	1.929	0.214	1.282	1.715
1862	1.733	0.602	1.333	1.627	0.884	1.244	2.043	0.708	1.331	1.862	0.745	1.367	2.043	0.602	1.323	1.441
1863	1.878	0.692	1.346	1.752	0.742	1.313	1.937	0.442	1.326	2.017	0.567	1.310	1.946	0.442	1.332	1.504
1864	1.690	0.711	1.256	1.789	0.772	1.337	1.764	0.314	1.241	1.857	0.582	1.260	1.790	0.314	1.252	1.476
1865	1.807	0.311	1.249	1.636	0.825	1.289	1.942	0.439	1.291	1.794	0.359	1.250	1.942	0.311	1.276	1.631
1866	1.919	0.635	1.311	1.732	0.775	1.268	2.054	0.565	1.329	2.430	0.389	1.352	2.430	0.565	1.323	1.865
1867	1.762	0.814	1.315	1.586	0.791	1.251	1.773	0.461	1.312	1.951	0.630	1.379	1.870	0.320	1.311	1.550

Maximum, minimum, and mean temperature for each month.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	45	—21	15.7	39	—15	14.2	61	6	30.5	72	21	37.8	86	27	53.0	87	45	60.1
1861	33	—14	16.8	45	—37	18.1	49	— 9	22.1	62	11	38.5	74	19	46.0	95	33	59.4
1862	33	—25	12.8	31	—23	8.4	42	—15	23.2	59	— 5	34.7	80	26	46.5	88	30	55.3
1863	42	— 8	22.9	45	— 8	17.6	47	— 6	22.5	70	8	41.5	94	20	51.6	95	30	57.4
1864	43	—34	14.8	41	—16	19.9	50	—13	22.0	57	12	35.8	82	19	49.5	97	30	65.5
1865	34	—31	15.3	48	—21	20.5	59	—22	21.9	75	7	35.8	86	22	48.8	95	38	57.9
1866	43	—17	17.0	46	—19.5	13.5	48	—16	16.4	78.5	4	37.8	74	20.5	45.5	89	30	59.3
1867	30.5	—23	13.8	44	—20	15.7	50	—18	15.3	67	14	36.8	63.5	18	40.8	91	39.5	61.3

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859				86		68.6	65		57.5	69		44.5	50		31.9	34	—20	12.7
1860	86	49	63.7	89	42	61.7	85	20	52.7	63	24	44.1	54	— 3	31.2	38	—16	19.3
1861	87	37	63.2	95	33	63.3	89.5	33	57.0	76	22	45.6	47	— 1	31.8	47	— 7	24.4
1862	94	43	64.7	86	41	63.4	88	29	56.0	74	19	44.6	49	2	29.6	49	—13	24.2
1863	83	34	61.4	94	35	61.9	89	20	51.8	63	16	39.5	55	— 3	31.2	44	— 3	23.4
1864	97	45	67.0	98	44	68.5	84	31	54.2	82	28	43.0	50	— 3	31.2	47	—15	15.7
1865	84	30	61.1	94.5	35	64.4	90.5	32.5	65.8	77.5	21.5	43.1	69	21.5	40.7	41	—14	17.5
1866	94.5	39.5	67.9	83	38.5	59.5	88.5	29	55.1	88.5	23	47.9	62	16	35.0	53	—14	19.9
1867		35	66.1		41	67.0		27	56.4		4	47.6		— 4	33.2		—55	16.6

ONTONAGON, MICHIGAN.

Year.	Maximum, minimum, and mean temperature for seasons and years from 1859 to 1867, inclusive.															
	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							69		44.6							
1860	86	6	40.4	89	42	61.8	85	— 3	42.7	45	—21	14.2	89	— 21	40.3	110
1861	74	— 9	35.5	95	33	62.0	89.5	— 1	44.8	45	—37	12.1	95	—37	40.5	132
1862	80	—15	34.8	94	30	61.1	88	2	43.4	47	—25	15.2	94	—25	38.6	119
1863	94	— 6	38.5	95	30	60.4	89	— 3	40.8	49	—13	21.6	95	— 8	40.3	103
1864	82	—13	35.8	98	30	67.0	84	— 3	42.8	44	—34	19.4	98	—34	40.6	132
1865	86	—22	35.5	95	30	61.1	90.5	21.5	49.9	48	—31	17.2	95	—31	40.5	126
1866	78	—16	33.2	94.5	30	62.2	88.5	16	46.0	46	—19.5	16.0	94.5	—19.5	39.5	114
1867	67	—18	31.0	.....	35	64.8	.....	— 4	45.7	53	—23	16.5	.....	—23	39.2	.....

ONTONAGON, MICHIGAN.—ALTITUDE 610 FEET.

Year.	Amount of rain and melted snow for months, seasons, and years, in United States inches and decimals.																
	Jan.	Feb.	Mar.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859								2.36	2.03	1.15	1.50	2.46			4.68		
1860	2.12	1.16	0.74	0.98	2.04	1.14	1.36	2.38	1.75	3.26	1.32	1.84	3.76	4.88	6.33	5.74	20.09
1861	3.14	1.25	2.18	4.17	2.33	5.02	2.92	1.16	3.18	2.54	2.31	2.86	8.68	9.10	8.03	6.23	33.06
1862	4.02	1.35	2.37	2.46	1.51	0.42	0.91	4.79	3.40	2.07	0.48	3.25	6.34	6.12	5.95	8.23	27.03
1863	2.43	2.92	0.72	0.65	1.69	1.81	2.35	4.01	2.72	2.30	0.87	0.92	3.06	8.17	5.89	8.60	23.39
1864	1.54	1.52	0.35	0.17	2.74	0.63	3.65	1.88	1.83	1.57	3.22	2.98	3.26	6.16	6.69	3.98	22.08
1865	1.60	0.55	2.08	2.63	2.66	3.15	5.13	1.55	2.20	1.00	0.46	3.78	7.37	9.83	3.66	5.15	26.81
1866	1.60	1.60	1.60	1.14	1.84	3.14	3.10	2.04	1.93	3.82	2.30	1.61	4.07	8.28	8.05	6.99	25.29
1867	1.60	1.60	1.60	2.22	1.38	3.66	3.26	1.65	3.59	2.33	0.89	1.59	2.83	8.57	6.74	5.45	23.57

MARQUETTE, MICHIGAN.—ALTITUDE 634 FEET.

Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	1.782	0.552	1.216	1.678	0.444	1.262	1.715	0.552	1.224	1.848	0.507	1.280	1.580	0.721	1.216	1.591	0.787	1.270
1861	1.861	0.713	1.282	1.648	0.542	1.195	1.957	0.495	1.315	1.754	0.713	1.230	1.750	0.284	1.246	1.528	0.745	1.261
1862	1.912	0.875	1.307	1.670	0.639	1.283	1.637	0.535	1.229	1.689	0.658	1.347	1.683	0.955	1.296	1.620	0.863	1.297
1863	1.708	0.698	1.243	1.921	0.646	1.424	1.807	0.732	1.347	1.757	0.721	1.366	1.534	0.744	1.292	1.734	0.619	1.276
1864	1.698	0.548	1.165	1.635	0.516	1.074	1.560	0.503	1.153	1.628	1.000	1.289	1.410	0.665	1.171	1.571	0.795	1.258
1865	1.612	0.797	1.210	1.780	0.944	1.330	1.601	0.563	1.171	1.674	0.382	1.200	1.530	0.673	1.195	1.487	0.748	1.194
1866	2.421	0.730	1.354	1.853	0.612	1.282	1.857	0.591	1.388	1.596	0.594	1.231	1.566	0.774	1.205	1.614	0.722	1.135
1867	1.723	0.743	1.230	1.791	0.607	1.263	1.707	0.570	1.348	1.544	0.729	1.191	1.568	0.878	1.248	1.452	0.674	1.203

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	1.676	0.784	1.350	1.606	1.055	1.393	1.726	0.766	1.335	1.668	0.587	1.332	1.885	0.480	1.314	1.687	0 825	1.332
1860	1.622	0.700	1.252	1.602	0.956	1.284	1.842	0.703	1.347	1.833	0.698	1.357	1.659	0.355	1.192	1.953	0.753	1.354
1861	1.625	0.004	1.259	1.663	1.022	1.359	1.861	0.772	1.309	1.685	0.641	1.223	1.665	0.405	1.181	1.881	0.663	1.351
1862	1.487	0.867	1.200	1.573	0.900	1.276	1.737	0.941	1.314	1.850	0.672	1.255	2.157	0.842	1.380	1.975	0.820	1.284
1863	1.647	0.980	1.308	1.574	0.804	1.270	1.744	0.884	1.340	1.852	0.500	1.329	1.777	0.708	1.226	1.782	0.527	1.334
1864	1.587	0.966	1.240	1.480	0.758	1.211	1.493	0.739	1.196	1.560	0.675	1.167	1.656	0.582	1.132	1.740	0.312	1.097
1865	1.595	0.862	1.315	1.592	0.964	1.339	1.642	0.910	1.291	1.475	0.621	1.342	1.932	0.433	1.250	1.660	0.391	1.194
1866	1.475	0.872	1.215	1.656	0.935	1.276	1.594	0.704	1.246	1.810	0.434	1.282	2.002	0.812	1.263	1.890	0.692	1.236
1867	1.530	0.787	1.241	1.511	0.947	1.250	1.649	0.732	1.303	1.725	0.604	1.345	1.853	0.520	1.185	1.819	0.285	1.265

MARQUETTE, MICHIGAN. + 28 INCHES.

Year.	Maximum, minimum, and mean barometrical pressure, reduced to 32° Fahr., for seasons.															
	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							1.885	0.480	1.327							
1860	1.848	0.507	1.240	1.622	0.700	1.268	1.842	0.355	1.298	1.782	0.444	1.270	1.953	0.355	1.271	1.598
1861	1.957	0.284	1.263	1.663	0.745	1.293	1.861	0.405	1.238	1.953	0.542	1.277	1.957	0.284	1.268	1.673
1862	1.689	0.535	1.291	1.620	0.863	1.258	2.157	0.672	1.316	1.912	0.639	1.314	2.157	0.535	1.289	1.622
1863	1.807	0.721	1.335	1.734	0.619	1.285	1.852	0.500	1.298	1.975	0.646	1.317	1.921	0.500	1.313	1.421
1864	2.628	0.503	1.204	1.587	0.758	1.236	1.656	0.582	1.165	1.782	0.516	1.191	1.740	0.312	1.179	1.428
1865	1.674	0.382	1.189	1.595	0.748	1.283	1.932	0.433	1.294	1.780	0.312	1.212	1.932	0.382	1.252	1.650
1866	1.857	0.591	1.275	1.656	0.722	1.209	2.002	0.434	1.264	2.421	0.391	1.277	2.421	0.434	1.259	1.987
1867	1.707	0.570	1.262	1.530	0.674	1.231	1.725	0.520	1.278	1.890	0.607	1.243	1.819	0.285	1.256	1.534

MARQUETTE, MICHIGAN.

Year.	Maximum, minimum, and mean temperature for each month, from the year 1859 to 1867, inclusive.																	
	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	51	—14	18.8	46	—13	17.2	62	15	33.1	68	15	37.5	86	32	53.0	95	45	60.1
1861	35	—18	17.8	53	—33	19.8	47	—19	21.8	58	14	38.0	85	16	46.0	92	31	59.9
1862	37	—18	15.0	39	—11	11.1	46	0	25.1	60	3	36.0	90	24	50.0	83	31	56.6
1863	45	—25	25.8	44	—22	20.2	47	— 1	25.0	73	10	41.5	93	28	53.5	95	35	59.3
1864	47	—31	17.5	47	—22	21.1	59	—11	25.4	66	17	37.4	88	25	51.1	10.1	35	64.7
1865	45	— 7	17.2															

MARQUETTE, MICHIGAN.

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	93	40	65.0	97	43	63.7	74	35	54.1	85	25	41.1	53	15	32.8	39	—19	14.6
1860	93	41	62.8	90	38	61.4	81	23	52.8	69	25	45.2	62	— 2	31.0	66	— 5	19.8
1861	90	38	63.2	97	38	63.6	87	32	56.2	72	24	46.4	48	2	33.0	51	— 7	26.6
1862	103	33	65.6	82	39	64.2	92	31	56.9	70	15	44.6	66	10	30.1	46	1	26.0
1863	88	37	61.2	91	38	62.8	93	24	54.3	76	19	41.2	.....	.....	31.7	47	3	25.3
1864	101	43	69.9	100	45	71.3	80	33	56.4	65	29	44.6	57	2	33.4	45	16	19.9
1865	91.5	38	62.1	94	43.5	66.9	92	40	66.7	84	25	43.7	69	20	39.9	40	— 5	20.1
1866	99.5	43	71.6	84.5	43	60.7	82	32.5	55.3	85	22.5	49.6	57.5	22	35.2	60 5	— 5	22.3
1867	93.5	41	67.8	97.5	41	68.5	87.5	27	58.5	82	28	49.1	63.5	— 4	35.1	39	—10	18.9

MARQUETTE, MICHIGAN.

Maximum, minimum, and mean temperature for seasons and years, from 1859 to 1867, inclusive.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859	.....	.....	.....	.....	.....	.....	85	15	42.7	.....	.....	.....	.....	.....	.....	.....
1860	86	15	41.2	95	38	61.4	81	— 2	43.0	51	—19	16.9	95	—14	41.0	109
1861	85	—19	35.3	97	31	62.2	87	2	45.2	53	—33	19.1	97	—33	41.0	130
1862	90	0	37.0	103	31	62.1	92	10	43.8	51	—18	17.6	103	—18	40.1	121
1863	93	— 1	39.9	95	35	61.2	93	19	42.4	46	—25	23.9	95	—25	41.8	120
1864	88	—11	38.0	101	35	68.3	80	2	44.8	47	—31	21.3	101	—31	42.7	132
1865	84	—17	38.8	95.5	38	63.5	92	20	50.1	48	— 7	20.6	95.5	—17	43.3	112.5
1866	86.5	—11	34.8	100.5	30	64.6	85	22	46.7	42	—25.5	16.2	100.5	—25.5	40.8	126
1867	74	— 8	35.1	97.5	41	66.9	87.5	— 4	47.6	60.5	—15	19.1	97.5	—15	41.9	412.5

MARQUETTE, MICHIGAN.

Year.	Amount of rain and melted snow for months, seasons, and years, in United States inches and decimals.															
	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859							3.26	3.45	3.54	1.42	3.73	2.24			8.96		
1860	1.41	2.90	2.00	2.54	2.26	2.89	0.82	2.13	1.05	2.50	2.35	2.94	6.80	5.84	5.90	6.55	25.79
1861	4.16	4.57	1.15	2.65	3.52	7.11	2.47	1.52	5.42	2.10	3.35	0.96	7.32	11.10	10.87	11.67	38.98
1862	2.03	0.96	1.78	3.32	2.71	1.24	2.75	3.93	4.32	3.07	2.10	2.03	8.01	7.92	9.49	3.95	36.35
1863	1.96	1.65	1.93		1.21	2.60	4.24	7.34	2.66	4.39	2.04	3.06	(3.14)	14.18	9.09	5.64	(33.08)
1864	1.79	1.87	1.14	1.39	0.55	0.31	1.95	1.73	2.29	2.17	4.24	2.89	3.08	3.99	8.70	6.72	22.32
1865	1.00	2.07	3.99	3.93	2.25	3.98	3.26	1.11	1.01	1.84	0.59	1.05	10.17	8.35	3.44	5.97	26.08
1866	2.37	1.21	1.97	1.75	0.78	4.36	3.59	2.95	2.15	3.99	2.60	1.77	4.50	10.90	8.74	4.63	29.49
1867	1.95	1.48	1.84	0.57	1.81	1.85	2.21	2.07	2.30	1.37	1.56	2.33	3.22	6.13	5.23	5.20	20.34

THUNDER BAY ISLAND, MICHIGAN.—ALTITUDE 614 FEET.

Year.	Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.																	
	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	1.864	0.907	1.388	1.751	0.578	1.337	1.879	0.050	1.130	1.776	0.558	1.295	1.842	0.867	1.393	1.824	0.991	1.367
1860	1.874	0.683	1.306	1.790	0.551	1.327	1.683	0.644	1.262	1.984	0.481	1.309	1.715	0.876	1.288	1.643	0.732	1.299
1861	1.979	0.757	1.355	1.746	0.573	1.245	1.887	0.583	1.348	1.830	0.827	1.287	1.693	0.530	1.293	1.581	0.875	1.319
1862	1.885	0.884	1.442	1.806	0.765	1.372	1.632	0.700	1.291	1.916	0.756	1.435	1.900	0.928	1.336	1.735	0.879	1.350
1863	1.893	0.563	1.319	1.992	0.809	1.472	1.856	0.850	1.375	1.707	0.534	1.404	1.620	0.761	1.332	1.661	0.677	1.315
1864	1.825	0.734	1.306	1.823	0.641	1.199	1.765	0.493	1.252	1.763	0.981	1.363	1.544	0.956	1.269	1.799	0.786	1.430
1865	1.838	1.039	1.350	1.881	0.992	1.455	1.777	0.423	1.292	1.880	0.485	1.366	1.727	0.817	1.349	1.608	0.956	1.362
1866																		
1867																		

Year.	Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.																	
	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	1.806	0.835	1.406	1.625	1.161	1.351	1.839	0.753	1.384	1.688	0.979	1.377	1.967	0.557	1.423	2.069	0.969	1.406
1860	1.683	0.782	1.308	1.667	0.918	1.333	1.834	0.939	1.414	1.776	0.722	1.396	1.677	0.506	1.218	1.956	0.630	1.400
1861	1.604	0.872	1.306	1.656	1.120	1.412	1.903	1.053	1.393	1.747	0.668	1.335	1.771	0.744	1.261	1.917	0.820	1.450
1862	1.592	0.959	1.275	1.690	1.047	1.355	1.796	0.872	1.392	1.853	0.771	1.334	2.129	0.813	1.376	2.067	0.941	1.367
1863	1.640	1.072	1.349	1.630	1.883	1.363	1.840	0.895	1.447	1.950	0.864	1.400	1.866	0.772	1.300	1.977	0.705	1.430
1864	1.656	1.151	1.411	1.636	1.809	1.335	1.684	0.939	1.358	1.666	0.873	1.296	1.790	0.421	1.290	1.941	0.519	1.243
1865	1.701	0.980	1.402	1.652	1.048	1.457	1.700	1.171	1.442	1.815	0.658	1.398	2.070	0.957	1.417	.....	.....	(1.383)
1866	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1867	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

THUNDER BAY ISLAND, MICHIGAN. + 28 INCHES.

Year.	Maximum, minimum, and mean barometrical pressure reduced to 32° Fahr., for seasons.															Range.
	Spring.			Summer.			Autumn.			Winter.			Year.			
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859	1.879	0.050	1.292	1.824	0.835	1.375	1.967	0.557	1.395	.....	.....	.....	2.069	0.050	1.358	2.019
1860	1.984	0.481	1.286	1.683	0.732	1.313	1.834	0.506	1.343	2.069	0.551	1.346	1.984	0.481	1.321	1.503
1861	1.887	0.530	1.309	1.656	0.872	1.346	1.903	0.668	1.329	1.979	0.573	1.333	1.979	0.530	1.333	1.449
1862	1.916	0.760	1.354	1.735	0.879	1.327	2.129	0.771	1.367	1.917	0.765	1.421	2.129	0.760	1.309	1.429
1863	1.856	0.534	1.370	1.661	0.677	1.342	1.950	0.772	1.382	2.067	0.563	1.386	1.992	0.534	1.375	1.458
1864	1.765	0.493	1.295	1.799	0.786	1.392	1.790	0.421	1.315	1.977	0.640	1.312	1.941	0.421	1.312	1.520
1865	1.880	0.423	1.336	1.701	0.956	1.407	2.070	0.658	1.419	1.941	0.519	1.349	.....	.....	(1.389)	.....
1866	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1867	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

THUNDER BAY ISLAND, MICHIGAN.

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	38	—4	22.8	37	1	23.3	46	13	32.3	48	23	34.9	58	36	46.0	72	35	53.6
1860	44	—6	22.4	40	— 5	20.7	49	12	31.7	46	17	35.6	57	34	46.3	70	46	57.1
1861	35	1	21.6	46	—25	24.0	43	—11	24.0	62	22	37.6	69	25	43.8	79	41	55.5
1862	37	2	22.6	38	—10	19.9	45	9	29.8	53	17	37.0	64	31	46.7	76	40	57.0
1863	38	0	27.7	36	— 6	23.5	36	8	25.6	45	8	37.7	56	34	48.9	66	40	58.6
1864	47	—17	22.4	47	—20	24.0	44	—10	26.4	52	25	37.6	69	30	47.1	90	35	60.5
1865	40.5	—7.5	19.2	40	—65	23.6	51	—11.5	29.7	59	10	38.4	72	27	47.0	77	39	58.4
1866	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1867	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	79	44	63.6	76	51	65.7	71	36	55.2	72	29	43.1	51	25	35.8	36	—5	19.5
1860	76	50	61.5	73	51	62.8	73	34	55.0	61	32	47.0	60	11	36.2	38	5	24.5
1861	82	48	63.0	81	49	65.0	77	40	58.4	70	31	49.6	52	20	37.5	51	7	31.8
1862	85	47	65.3	82	50	66.4	77	41	58.4	70	28	47.3	50	20	34.9	42	3	29.1
1863	73	44	64.9	81	40	63.9	73	33	54.9	65	29	45.1	54	8	37.0	45	2	27.6
1864	90	51	67.6	93	51	70.3	74	39	57.0	64	29	45.4	54	16	36.0	46	—1	23.8
1865	80	41	62.9	82	46	64.9	81	41	64.8	72.5	26	46.6	60.5	23	41.2	.....	.....	(26.0)
1866	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1867	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Maximum, minimum, and mean temperature for seasons and years from 1859 to 1867, inclusive.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859	58	13	37.8	79	35	61.0	72	25	44.7	.....	.....	.....	79	— 5	41.3	84
1860	57	12	37.9	76	46	60.5	73	11	46.1	44	— 6	20.9	76	— 6	41.7	82
1861	69	—11	35.1	82	41	61.2	77	20	48.5	46	—25	23.4	82	—25	42.6	107
1862	64	9	37.9	85	40	62.9	77	20	46.9	51	—10	24.8	85	—10	42.9	95
1863	56	8	37.4	81	40	62.5	73	8	45.7	42	— 6	26.8	81	— 6	42.9	87
1864	69	—10	37.0	93	35	66.1	74	16	46.1	47	—20	24.7	93	—20	43.2	113
1865	72	—11.5	38.4	82	39	62.1	81	26	50.9	46	— 7.5	22.2	82	—11.5	(43.8)	93.5
1866	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1867	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

THUNDER BAY ISLAND, MICHIGAN.

Amount of rain and melted snow for months, seasons, and years, in United States inches and decimals.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859	5.97	2.53	4.28	3.79	1.38	2.34	3.06	0.70	3.95	2.04	4.51	2.59	9.45	6.10	10.50	.....	37.14
1860	2.26	3.66	1.52	2.97	1.69	1.69	2.37	2.26	3.45	2.46	1.32	2.23	6.18	6.32	7.23	8.51	27.88
1861	4.35	4.04	3.08	2.57	2.43	3.55	4.18	0.98	2.48	2.98	3.33	2.12	8.08	8.71	8.79	10.62	36.09
1862	2.78	1.27	1.69	3.91	3.19	0.97	2.20	5.49	8.58	4.05	1.39	1.40	8.79	8.66	14.02	6.17	36.92
1863	3.50	2.12	3.23	1.73	2.10	2.06	4.59	2.41	1.19	2.63	2.69	3.04	7.06	9.06	6.51	7.02	31.29
1864	2.13	2.99	2.63	3.03	1.68	2.06	1.92	0.87	2.22	3.24	3.49	5.67	7.34	4.85	8.95	8.16	31.93
1865	1.43	1.94	3.41	3.46	2.00	3.63	1.72	3.02	4.98	2.17	0.39	(3.17)	8.88	8.37	7.54	9.04	(31.32)
1866	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1867	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TAWAS CITY, MICHIGAN.—ALTITUDE 587 FEET.

Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	1.941	0.883	1.432	1.704	0.867	1.343	1.899	0.059	1.149	1.732	0.556	1.321	1.849	0.891	1.387	1.900	1.022	1.397
1860	1.883	0.725	1.338	1.831	0.595	1.338	1.696	0.734	1.302	1.981	0.570	1.318	1.721	0.901	1.284	1.633	0.627	1.294
1861	1.989	0.770	1.396	1.772	0.573	1.258	1.862	0.618	1.355	1.809	0.858	1.285	1.705	0.545	1.302	1.584	0.870	1.328
1862	1.948	0.736	1.433	1.794	0.670	1.364	1.595	0.655	1.247	1.854	0.746	1.447	1.763	0.856	1.357	1.773	0.938	1.370
1863	1.936	0.635	1.351	2.017	0.715	1.486	1.862	1.000	1.389	1.814	0.628	1.417	1.659	0.770	1.348	1.682	0.720	1.337
1864	1.842	0.750	1.320	1.818	0.664	1.219	1.758	0.556	1.256	1.751	0.959	1.344	1.515	0.930	1.259	1.737	0.867	1.437
1865	1.875	0.950	1.357	1.894	0.796	1.458	1.802	0.558	1.295	1.896	0.567	1.372	1.746	0.852	1.334	1.599	0.962	1.343
1866	2.611	0.823	1.495	1.974	0.919	1.417	1.795	0.685	1.423	1.741	0.845	1.358	1.602	0.801	1.254	1.660	0.813	1.223
1867	1.862	0.687	1.339	1.817	0.721	1.302	1.741	0.687	1.378	1.639	0.736	1.208	1.635	0.781	1.200	1.510	0.705	1.252

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	1.815	0.907	1.409	1.605	1.161	1.363	1.841	0.792	1.432	1.707	1.018	1.399	2.132	0.690	1.391	2.041	0.983	1.393
1860	1.676	0.807	1.310	1.667	1.020	1.343	1.848	0.980	1.445	1.750	0.771	1.406	1.641	0.542	1.304	2.007	0.658	1.420
1861	1.604	0.877	1.309	1.615	1.102	1.406	1.850	1.046	1.368	1.839	0.689	1.353	1.744	0.752	1.260	1.914	0.849	1.469
1862	1.669	0.946	1.305	1.723	0.997	1.387	1.774	0.948	1.430	1.870	0.942	1.374	2.130	0.846	1.399	2.109	0.951	1.405
1863	1.692	1.111	1.376	1.687	0.995	1.406	1.892	0.955	1.484	1.986	0.922	1.428	1.892	0.861	1.333	1.937	0.666	1.435
1864	1.629	1.147	1.404	1.692	0.860	1.328	1.656	0.949	1.358	1.684	0.708	1.297	1.798	0.441	1.299	2.039	0.579	1.257
1865	1.704	0.996	1.384	1.687	1.065	1.444	1.702	1.114	1.421	1.773	0.648	1.401	2.041	0.686	1.408	1.846	0.860	1.395
1866	1.584	0.913	1.308	1.731	0.967	1.320	1.630	0.935	1.360	1.907	0.735	1.428	1.573	0.935	1.262	1.924	0.472	1.327
1867	1.764	0.985	1.312	1.603	1.010	1.292	1.714	1.086	1.365	1.842	0.719	1.321	1.535	0.797	1.363	1.949	0.571	1.258

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859	1.899	0.059	1.285	1.900	0.907	1.390	2.132	0.690	1.407	.....	.....	.....	2.132	0.059	1.368	2.073
1860	1.981	0.570	1.301	1.676	0.627	1.315	1.848	0.542	1.385	2.041	0.595	1.356	2.007	0.542	1.342	1.465
1861	1.862	0.515	1.314	1.615	0.870	1.347	1.850	0.689	1.327	2.007	0.573	1.358	1.989	0.545	1.341	1.444
1862	1.854	0.655	1.350	1.773	0.938	1.354	2.130	0.846	1.400	1.948	0.670	1.422	2.130	0.655	1.376	1.475
1863	1.862	0.628	1.385	1.692	0.720	1.373	1.986	0.861	1.415	2.109	0.635	1.414	2.017	0.628	1.399	1.289
1864	1.758	0.556	1.286	1.737	0.860	1.380	1.798	0.441	1.318	1.937	0.664	1.325	2.039	0.441	1.314	1.598
1865	1.896	0.558	1.334	1.704	0.962	1.390	2.041	0.648	1.410	2.039	0.579	1.357	2.041	0.558	1.384	1.483
1866	1.795	0.685	1.345	1.731	0.813	1.284	1.907	0.735	1.350	2.611	0.823	1.436	2.611	0.472	1.348	2.139
1867	1.741	0.687	1.262	1.764	0.705	1.285	1.842	0.719	1.350	1.924	0.472	1.323	1.949	0.571	1.299	1.378

TAWAS CITY, MICHIGAN.

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	41	0	24.2	44	0	25.7	56	11	33.1	58	24	38.7	66	35	52.3	75	36	58.7
1860	46	— 2	23.4	48	—16	21.6	52	13	34.8	53	15	39.6	71	30	54.0	78	52	63.5
1861	39	— 9	21.2	47	—25	24.8	47	—10	36.3	60	26	40.3	65	28	47.7	78	44	61.9
1862	37	— 5	20.9	37	— 9	20.9	41	7	28.9	57	21	38.8	71	29	50.6	76	39	58.3
1863	43	—11	28.2	41	2	24.7	42	6	28.0	60	9	40.4	81	33	53.8	76	42	59.5
1864	50	—16	21.9	52	—14	25.5	46	— 5	27.7	54	26	39.3	78	29	53.8	90	32	63.3
1865	39	— 4	18.5	57	— 9	23.3	54.5	—10	30.8	61	18	41.5	73	28	52.4	85	39	66.5
1866	40	—25	18.7	40	—16	19.6	48	— 1	24.3	.....	18	40.6	.....	17	48.7	.....	27	62.1
1867	.....	—15	17.2	.....	0	27.6	.....	3	27.1	.....	21	41.0	.....	23	45.1	.....	43	65.2

TAWAS CITY, MICHIGAN.

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	83	47	68.4	81	48	68.7	73	39	57.9	72	26	45.0	54	24	37.2	41	—6	20.6
1860	78	51	66.6	79	50	65.5	77	41	57.3	59	33	48.8	55	11	36.9	41	—2	25.0
1861	80	48	66.2	82	40	67.4	85	31	60.0	74	23	50.6	59	17	36.4	60	3	31.9
1862	82	44	67.0	86	45	67.4	79	43	60.3	75	20	48.3	59	17	35.2	51	7	29.9
1863	84	42	65.7	85	41	65.3	77	28	56.1	63	23	43.4	54	12	37.1	47	2	27.7
1864	86	48	69.9	87	43	69.4	75	35	57.1	59	29	44.3	53	13	35.5	45	—6	23.0
1865	83	40.5	61.7	81	42	65.8	83.5	39	60.0	72	27	45.8	59	25	32.8	47	—2	25.7
1866	.....	46	71.2	.....	31.5	61.7	.....	31	56.1	.....	30	53.5	.....	22	39.9	.....	6	24.3
1867	.....	33.5	71.4	.....	40.5	70.0	.....	36	60.8	.....	28	50.7	.....	14.5	36.7	.....	2	22.0

TAWAS CITY, MICHIGAN.

Maximum, minimum, and mean temperature for seasons and years, from 1859 to 1867, inclusive.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859	66	11	42.0	83	36	65.2	73	24	46.7	.....	.....	.....	83	— 6	44.4	89
1860	71	13	42.8	79	50	65.2	77	11	47.6	48	—16	21.9	79	—16	44.7	95
1861	65	—10	38.1	82	40	65.1	85	17	49.0	47	—25	23.7	85	—25	44.5	110
1862	71	7	39.4	86	39	64.2	79	17	47.9	60	— 9	24.6	86	— 9	43.9	95
1863	81	6	40.7	85	41	63.5	77	12	45.5	51	—11	27.6	85	—11	44.1	96
1864	78	— 5	40.3	90	32	67.5	75	13	46.0	52	—16	25.0	90	—16	44.3	106
1865	73	—10	41.6	85	39	64.7	83.5	25	50.2	57	— 9	21.6	85	—10	44.7	95
1866	.....	— 1	37.9	.....	27	65.0	.....	22	49.8	47	—25	21.3	.....	—25	43.4	.....
1867	.....	3	37.7	.....	33	69.9	.....	14.5	49.4	.....	—15	23.0	.....	—15	44.6	.....

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859	1.07	0.26	2.89	2.10	1.65	1.25	1.22	0.37	1.91	1.38	2.82	1.74	6.64	2.84	6.11	3.07	18.66
1860	1.60	0.97	1.39	1.85	1.59	1.07	1.62	2.38	0.95	2.57	0.85	0.85	4.83	5.07	4.37	4.31	17.69
1861	1.44	1.12	2.04	2.81	1.78	1.24	1.70	2.22	2.08	1.29	1.97	0.91	6.63	5.16	5.34	3.41	20.60
1862	1.62	0.53	1.85	2.20	1.40	1.33	2.24	3.58	4.56	2.93	1.78	0.74	5.45	7.15	9.25	3.06	24.74
1863	2.06	1.53	2.51	1.92	2.84	1.17	3.69	4.67	0.46	3.97	3.15	3.02	7.27	9.53	7.58	4.33	30.99
1864	1.81	1.49	1.10	2.86	1.20	0.82	1.19	0.30	1.06	1.37	3.14	1.67	5.16	2.31	6.57	6.32	19.01
1865	0.50	1.20	3.64	3.99	0.73	3.69	1.71	1.61	6.65	2.04	0.82	0.77	8.36	7.01	9.51	3.37	27.35
1866	1.51	0.60	1.90	0.54	2.49	3.98	0.30	2.75	2.51	0.26	1.27	1.45	4.93	7.03	4.04	2.88	19.56
1867	1.82	0.50	1.20	1.59	2.05	2.19	2.49	3.49	1.03	0.99	0.97	1.87	4.85	8.17	2.99	3.77	20.20

MILWAUKEE, WISCONSIN—ALTITUDE 604 FEET.

Year.	Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.																	
	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	2.003	0.758	1.393	1.870	0.529	1.378	1.777	0.727	1.345	1.999	0.511	1.322	1.649	0.805	1.250	1.641	0.770	1.325
1861	1.863	0.665	1.374	1.767	0.635	1.264	1.862	0.729	1.364	1.604	0.831	1.242	1.753	0.447	1.293	1.593	1.002	1.350
1862	2.011	1.051	1.451	1.873	0.641	1.404	1.633	0.655	1.222	1.702	0.738	1.399	1.743	0.904	1.355	1.622	1.008	1.361
1863	1.706	0.808	1.338	1.892	0.811	1.476	1.800	0.972	1.389	1.746	0.768	1.389	1.595	0.875	1.329	1.730	0.943	1.363
1864	1.868	0.877	1.354	1.913	0.637	1.273	1.664	0.677	1.227	1.650	1.060	1.320	1.590	0.983	1.271	1.689	0.965	1.414
1865	1.806	1.073	1.397	1.854	0.875	1.415	1.736	0.721	1.299	1.879	0.787	1.332	1.585	0.903	1.308	1.588	0.968	1.326
1866	2.503	0.683	1.484	1.921	0.927	1.456	1.888	0.720	1.455	1.710	0.921	1.327	1.603	0.769	1.278	1.608	0.813	1.258
1867	1.879	0.802	1.339	1.909	0.752	1.327	1.771	0.772	1.425	1.650	0.934	1.275	1.616	0.922	1.264	1.578	0.806	1.290

MILWAUKEE, WISCONSIN.—ALTITUDE 604 FEET.

Year.	Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.																	
	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859				1.522	1.074	1.263	1.713	0.803	1.288	1.654	0.828	1.310	1.788	0.549	1.278	1.612	0.816	1.323
1860	1.683	0.902	1.331	1.604	1.118	1.358	1.820	0.971	1.442	1.784	0.750	1.409	1.680	0.589	1.286	1.952	0.760	1.457
1861	1.639	1.027	1.340	1.621	1.166	1.413	1.815	1.104	1.402	1.786	0.658	1.342	1.675	0.703	1.270	1.958	0.839	1.488
1862	1.623	1.047	1.313	1.702	1.052	1.389	1.717	1.075	1.409	1.945	0.945	1.387	2.034	0.910	1.420	2.032	0.911	1.416
1863	1.675	1.181	1.370	1.691	0.971	1.381	1.828	0.995	1.351	1.967	0.738	1.401	1.877	0.843	1.354	1.854	0.858	1.408
1864	1.696	1.139	1.395	1.661	1.007	1.345	1.582	0.935	1.314	1.696	0.836	1.298	1.757	0.767	1.291	1.970	0.552	1.284
1865	1.649	1.015	1.389	1.632	1.128	1.423	1.650	0.957	1.402	1.707	0.926	1.394	1.943	0.687	1.409	1.910	0.738	1.367
1866	1.616	1.035	1.338	1.661	1.017	1.357	1.639	0.925	1.365	1.895	0.687	1.423	2.040	0.898	1.350	1.842	0.615	1.353
1867	1.574	1.044	1.339	1.618	1.062	1.354	1.659	1.000	1.419	1.857	0.836	1.417	1.734	0.632	1.304	1.981	0.553	1.371

MILWAUKEE, WISCONSIN + 28 INCHES.

Year.	Maximum, minimum, and mean barometrical pressure reduced to 32° Fahr. for seasons.															Range.
	Spring.			Summer.			Autumn.			Winter.			Year.			
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							1.788	0.549	1.292							
1860	1.999	0.511	1.305	1.683	0.770	1.338	1.820	0.589	1.379	2.003	0.529	1.365	2.003	0.511	1.358	1.492
1861	1.862	0.447	1.299	1.639	1.002	1.367	1.815	0.658	1.338	1.952	0.635	1.365	1.958	0.447	1.345	1.511
1862	1.743	0.655	1.325	1.702	1.068	1.354	2.034	0.910	1.405	2.011	0.041	1.448	2.034	0.641	1.377	1.393
1863	1.800	0.768	1.369	1.730	0.943	1.371	1.967	0.738	1.369	2.032	0.808	1.410	1.967	0.738	1.379	1.229
1864	1.664	0.677	1.273	1.696	0.965	1.335	1.757	0.767	1.319	1.913	0.637	1.345	1.970	0.552	1.307	1.418
1865	1.879	0.721	1.313	1.649	0.968	1.379	1.943	0.687	1.402	1.970	0.552	1.365	1.943	0.721	1.373	1.222
1866	1.868	0.790	1.353	1.661	0.813	1.318	2.040	0.687	1.379	2.503	0.683	1.436	2.503	0.615	1.370	1.888
1867	1.771	0.779	1.255	1.618	0.806	1.328	1.857	0.632	1.380	1.009	0.615	1.340	1.981	0.553	1.326	1.428

MILWAUKEE, WISCONSIN.

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	48	—14	24.0	49	— 3	27.4	69	21	40.3	75	30	43.6	82	33	56.2	82	53	64.2
1861	42	—10	21.2	56	—16	27.5	62	5	32.0	76	30	44.9	85	27	50.7	87	40	64.6
1862	40	—21	20.3	41	—16	18.7	53	4	32.4	70	22	41.6	83	33	53.6	87	39	60.8
1863	50	5	29.8	47	—12	26.8	48	11	31.4	67	22	45.0	84	32	55.5	90	43	63.7
1864	49	—30	18.8	48	—18	26.0	52	— 1	30.7	61	30	40.1	91	30	55.3	97	39	65.2
1865	42	— 8	18.6	50	5	27.1	58	— 5	31.7	72	16	43.7	85	34	52.9	94	42	67.2
1866	44	—10	19.5	50	—18	19.1	52	3	27.1	74	24	43.5	88	32	50.4	92	42	64.3
1867	42	—16	17.5	47	—11	27.4	47	— 7	26.1	65	29	43.0	70	28	46.6	92	46	67.4

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859				92	55		81	45	59.3	79	30	48.2	69	19	40.6	46	—16	19.6
1860	84	49	69.0	85	44	66.8	82	40	58.7	75	32	50.0	58	— 3	36.1	45	— 5	24.8
1861	95	44	68.5	97	49	68.1	83	38	63.4	71	27	50.1	53	3	36.8	59	— 4	31.1
1862	92	47	70.9	93	50	70.6	87	42	62.0	81	23	51.2	55	20	35.2	55	0	30.6
1863	90	44	68.6	91	41	69.1	87	31	59.4	66	28	43.8	59	7	36.8	57	2	29.2
1864	94	52	71.3	92	49	69.9	84	40	60.7	60	28	45.7	60	3	35.3	53	—19	20.2
1865	91	44	63.4	89	45	67.1	88	42	62.4	77	25	48.3	61	26	40.5	46	— 9	22.9
1686	97	50	73.0	90	46	66.1	76	36	57.5	78	27	50.1	60	21	39.0	49	— 5	23.2
1867	91	46	69.2	94	43	70.2	91	40	62.0	80	32	52.2	67	1	40.7	56	3	25.7

MILWAUKEE, WISCONSIN.

Maximum, minimum, and mean temperature for seasons and years from 1859 to 1867, inclusive.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							81	19	49.4							
1860	82	21	46.7	85	44	66.7	82	— 3	48.3	49	—16	23.7	85	—14	46.8	99
1861	85	5	42.5	97	40	67.1	83	3	50.1	56	—16	24.5	97	—16	46.6	113
1862	83	4	42.5	93	39	67.4	87	20	49.4	59	—21	23.4	93	—21	45.5	114
1863	84	11	44.0	91	41	67.1	87	7	46.7	55	—12	29.1	91	—12	46.6	103
1864	91	— 1	42.0	97	39	68.8	84	3	47.2	57	—30	24.7	97	—30	44.9	127
1865	85	— 5	42.8	94	42	65.9	88	25	52.4	53	—19	22.0	94	— 9	46.0	103
1866	88	3	40.3	97	42	67.8	78	21	48.9	50	—18	20.5	97	—18	44.4	115
1867	70	— 7	38.6	94	43	68.9	91	1	51.6	49	—16	22.7	94	—16	45.3	110

MILWAUKEE, WISCONSIN.

Amount of rain and melted snow for months, seasons, and years, in United States inches and decimals.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859								0.20	3.54	1.52	3.12	0.64			8.18		
1860	0.53	1.40	0.33	0.33	3.34	4.15	1.95	2.80	2.50	2.09	2.61	2.71	4.00	8.90	7.20	2.57	24.74
1861	2.58	3.07	1.90	3.12	4.32	1.90	4.77	2.21	3.39	1.48	1.59	1.55	9.34	8.88	6.46	8.36	31.88
1862	3.41	0.48	2.10	5.34	5.11	3.86	4.09	2.94	5.40	3.26	1.28	1.37	12.55	10.89	9.94	5.44	39.12
1863	3.93	1.85	2.48	1.04	5.21	0.79	2.41	2.62	1.02	2.97	3.51	4.57	8.73	5.82	7.50	7.15	32.40
1865	2.15	0.42	2.52	3.01	2.74	0.03	7.07	0.61	2.93	1.63	2.61	1.99	8.27	7.71	7.17	7.14	27.71
1866	0.22	3.58	3.89	1.96	1.11	3.57	1.78	4.34	4.67	4.13	0.31	0.58	6.96	9.69	9.11	5.79	30.08
1867	2.58	1.64	1.50	3.04	2.06	4.83	2.73	3.95	3.88	2.76	1.32	3.00	6.60	11.51	7.96	4.74	33.29
	2.61	2.13	1.81	1.73	4.39	2.04	2.60	2.01	1.46	0.80	1.53	1.51	7.93	8.65	3.79	7.74	24.62

GRAND RIVER, MICHIGAN.—ALTITUDE 600 FEET.

Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr., + 28 inches.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	1.971	0.852	1.409	1.805	0.582	1.349	1.705	0.738	1.339	1.867	0.568	1.323	1.683	0.567	1.269	1.632	0.695	1.326
1861	1.845	0.620	1.357	1.718	0.352	1.262	1.827	0.499	1.362	1.675	0.796	1.239	1.717	0.579	1.309	1.588	1.098	1.369
1862	1.898	0.957	1.422	1.750	0.625	1.354	1.591	0.698	1.200	1.633	0.787	1.385	1.703	0.872	1.333	1.694	0.992	1.345
1863	1.772	0.832	1.327	1.880	0.890	1.467	1.786	0.954	1.370	1.728	0.752	1.377	1.584	0.831	1.330	1.691	0.910	1.348

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859							1.818	0.950	1.416	1.702	0.910	1.445	1.974	0.698	1.427	2.248	0.959	1.448
1860	1.660	0.892	1.315	1.609	1.099	1.353	1.807	0.960	1.441	1.754	0.907	1.403	1.607	0.588	1.267	2.127	0.723	1.448
1861	1.673	0.972	1.367	1.641	1.204	1.414	1.864	1.102	1.399	1.794	0.665	1.343	1.735	0.697	1.245	1.879	0.967	1.469
1862	1.588	1.075	1.314	1.689	1.033	1.390	1.734	1.094	1.428	1.842	0.970	1.387	1.973	0.649	1.360	2.059	0.838	1.405
1863	1.644	1.136	1.369															

GRAND HAVEN, MICHIGAN. + 28 INCHES.

Maximum, minimum, and mean barometrical pressure reduced to 32° Fahrenheit, for seasons.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							1.974	0.698	1.436							
1860	1.867	0.567	1.310	1.660	0.695	1.331	1.807	0.588	1.370	2.248	0.582	1.402	2.127	0.567	1.353	1.560
1861	1.827	0.499	1.310	1.673	0.972	1.383	1.864	0 665	1.329	2.127	0.352	1.356	1.879	0.352	1.346	1.527
1862	1.703	0.698	1.306	1.694	0.992	1.349	1.973	0.649	1.391	1.898	0.625	1.415	2.059	0.625	1.360	1.434
1863	1.786	0.752								2.059	0.832	1.400				

GRAND HAVEN, MICHIGAN.

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	40	0	26.2	52	5	25.8	63	21	37.3	67	27	45.2	77	40	60.1	81	50	66.0
1861	35	—4	24.0	50	—16	27.6	51	1	31.1	74	23	46.1	76	27	51.5	88	44	66.0
1862	41	—5	21.8	40	0	22.1	47	4	31.9	68	25	43.6	83	32	54.6	85	40	64.4
1863	69	7	31.2	50	2	26.6	48	10	31.6	76	8	46.1	88	30	58.1	88	28	65.2

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859				81	48		81	48	59.2	70	28	47.1	62	29	40.2	36	7	23.6
1860	84	59	70.7	86	48	67.7	79	28	57.9	65	20	49.1	60	9	36.6	47	6	25.1
1861	86	46	67.7	91	50	70.9	77	41	61.4	70	29	51.7	55	19	37.7	57	0	33.1
1862	87	48	72.3	89	50	72.2	80	39	63.0	75	17	51.4	59	11	37.5	52	6	33.1
1863	90	33	69.8															

GRAND HAVEN, MICHIGAN.

Maximum, minimum, and mean temperature for seasons and years from 1859 to 1867, inclusive.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							81	29	48.9							
1860	77	21	47.5	80	48	62.1	79	9	47.9	52	0	25.2	86	0	47.3	86
1861	76	1	42.9	91	44	68.2	77	19	50.3	50	—16	25.8	91	—16	47.4	107
1862	83	4	43.4	89	40	69.6	80	11	50.7	52	—5	25.7	89	—5	47.2	94
1863	86	8	45.1													

GRAND HAVEN, MICHIGAN.

Year.	Amount of rain and melted snow for months, seasons, and years, in United States inches and decimals.																
	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859	.....	.....	.....	.....	.....	.....	.....	.....	2.24	3.38	2.36	3.68	.....	.....	7.98	.....	.....
1860	1.60	1.60	0.64	0.96	3.46	2.54	3.76	3.88	3.40	2.30	3.99	0.82	5.06	10.18	9.69	6.88	28.95
1861	1.66	1.06	0.66	0.68	2.60	1.51	2.85	3.48	4.58	2.54	1.97	1.48	3.94	7.84	9.09	3.54	25.07
1862	1.41	1.04	2.22	1.66	2.74	2.12	1.36	4.26	0.20	1.07	2.86	0.96	6.62	7.77	4.13	3.93	21.93
1863	1.82	1.42	1.12	0.94	3.66	0.56	0.90	.....	.....	.....	.....	.....	5.72	.....	.....	4.20	.....

DETROIT, MICHIGAN.—ALTITUDE 587 FEET.

Year.	Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr., + 28 inches.																	
	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	1.949	0.873	1.464	1.693	0.940	1.353	1.821	0.469	1.254	1.700	0.699	1.239	1.752	0.994	1.373	.....	.....	.....
1860	1.964	0.926	1.384	1.832	0.637	1.433	1.641	0.882	1.302	1.958	0.562	1.314	1.686	0.991	1.274	1.612	0.608	1.296
1861	1.924	0.774	1.384	1.814	0.730	1.297	1.814	0.776	1.363	1.738	0.779	1.261	1.695	0.658	1.292	1.559	1.019	1.329
1862	1.971	0.861	1.423	1.780	0.663	1.377	1.556	0.690	1.213	1.789	0.793	1.416	1.702	0.918	1.345	1.782	0.933	1.333
1863	1.948	0.656	1.354	1.976	0.807	1.477	1.759	0.807	1.348	1.701	0.581	1.313	1.599	0.750	1.262	1.618	0.795	1.283
1864	1.888	0.914	1.403	1.918	0.690	1.288	1.705	0.598	1.269	1.718	0.951	1.312	1.548	0.964	1.249	1.721	0.921	1.427
1865	1.910	1.043	1.384	1.908	0.866	1.425	1.859	0 695	1.309	1.798	0.836	1.365	1.668	1.006	1.327	1.540	1.009	1.389
1866	2.630	0.844	1.506	2.073	1.033	1.444	1.872	0.872	1.468	1.752	0.852	1.398	1.654	0.664	1.289	1.727	0.813	1.314
1867	1.804	0.828	1.348	2.034	0.566	1.392	1.839	0.790	1.439	1.714	0.849	1.310	1.720	0.770	1.278	1.623	0.915	1.359

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.975	0.876	1.403
1860	1.641	0.963	1.326	1.704	1.035	1.345	1.800	1.106	1.442	1.698	0.790	1.394	1.630	0.637	1.272	1.988	0.760	1.439
1861	1.579	0.933	1.331	1.620	1.181	1.398	1.810	1.028	1.391	1.778	0.735	1.361	1.686	0.771	1.258	1.951	1.001	1.499
1862	1.666	1.046	1.305	1.678	1.155	1.396	1.707	0.983	1.429	1.799	0.881	1.401	2.029	0.879	1.386	2.039	0.852	1.415
1863	1.638	1.132	1.323	1.786	1.056	1.387	1.869	1.034	1.464	1.932	0.908	1.430	1.668	0.881	1.376	1.958	0.797	1.464
1864	1.612	1.129	1.409	1.680	0.946	1.325	1.598	1.028	1.344	1.609	0.941	1.303	1.796	0.708	1.342	2.009	0.704	1.289
1865	1.654	1.052	1.392	1.635	1.180	1.445	1.660	1.046	1.448	1.743	0.708	1.400	1.982	0.670	1.461	2.022	0.767	1.408
1866	1.692	1.105	1.413	1.727	0.986	1.386	1.756	1.001	1.430	1.979	1.014	1.492	2.099	0.907	1.428	1.936	0.636	1.391
1867	1.614	1.062	1.377	1.626	1.117	1.384	1.770	1.202	1.482	1.883	0.845	1.452	1.713	0.714	1.347	1.964	0.656	1.393

DETROIT, MICHIGAN. + 28 INCHES.

Maximum, minimum, and mean barometrical pressure reduced to 32° Fah., for seasons.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859	1.821	0.464	1.288													
1860	1.958	0.562	1.296	1.704	0.608	1.322	1.800	0.637	1.369	1.975	0.637	1.407	1.988	0.562	1.352	1.426
1861	1.814	0.658	1.305	1.620	0.933	1.352	1.810	0.735	1.336	1.988	0.730	1.373	1.951	0.658	1.347	1.293
1862	1.789	0.690	1.325	1.782	0.933	1.345	2.029	0.879	1.405	1.971	0.663	1.433	2.039	0.663	1.370	1.376
1863	1.759	0.581	1.308	1.786	0.795	1.331	1.932	0.881	1.423	2.039	0.656	1.415	1.976	0.581	1.373	1.395
1864	1.718	0.598	1.277	1.721	0.921	1.387	1.796	0.708	1.330	1.958	0.690	1.385	2.009	0.598	1.330	1.411
1865	1.859	0.695	1.330	1.654	1.006	1.402	1.982	0.708	1.436	2.009	0.704	1.366	2.022	0.695	1.394	1.327
1866	1.872	0.664	1.385	1.727	0.813	1.371	2.099	0.907	1.450	2.630	0.767	1.453	2.630	0.664	1.413	1.966
1867	1.839	0.770	1.342	1.626	0.915	1.373	1.883	0.714	1.427	2.034	0.566	1.377	2.034	0.566	1.379	1.468

DETROIT, MICHIGAN.

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859			33.1			32.2			43.3			46.9			67.0			
1860	49	—14	26.9	60	9	27.6	67	15	39.6	75	30	44.9	83	32	60.6	87	46	66.4
1861	43	1	24.3	64	—14	30.1	75	6	33.5	78	29	47.9	80	25	52.9	87	40	67.5
1862	47	4	44.5	47	1	25.1	49	9	32.3	89	28	46.2	80	33	56.7	84	41	64.0
1863	53	— 3	31.1	49	3	27.2	59	9	31.4	74	12	45.8	86	36	60.6	91	39	64.6
1864	63	—19	24.6	60	— 5	29.4	61	5	33.4	60	29	44.2	87	33	59.4	95	38	67.7
1865	42	1	21.5	48	— 2	28.0	70	9	38.4	74	25	48.2	85	33	58.5	91	46	72.3
1866	57	—14	22.3	50	—14	25.1	56	9	29.4	78	24	47.9	80	27	52.4	88	44	64.7
1867	43	—14	18.7	53	— 1	30.8	57	7	29.2	67	26	45.8	71	25	50.3	91	42	68.7

DETROIT, MICHIGAN.

Maximum, minimum, and mean temperature for each month, from the year 1859 to 1867, inclusive.

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																39	0	21.8
1860	89	48	68.6	88	42	68.1	81	33	57.9	74	29	50.2	66	7	37.3	41	— 3	25.1
1861	89	46	69.3	98	47	70.1	82	39	62.1	73	30	52.7	58	21	38.9	65	6	35.1
1862	95	48	72.4	91	49	71.6	86	41	63.4	82	23	51.3	70	24	38.2	58	10	33.5
1863	87	43	69.2	90	37	69.8	84	31	59.7	75	27	47.2	67	16	41.9	54	11	32.4
1864	95	53	74.3	93	46	71.4	82	37	60.7	75	28	47.7	80	18	38.0	55	— 4	25.8
1865	94	45	67.4	89	41	69.2	88	42	71.8	78	26	49.6	69	21	40.1	59	1	29.5
1866	92	50	72.1	82	41	64.0	82	34	57.5	77	29	51.6	61	19	38.7	54	6	25.9
1867	93	44	70.5	93	41	69.7	91	38	61.2	82	27	51.8	77	11	41.3	61	— 1	25.6

DETROIT, MICHIGAN.

Maximum, minimum, and mean temperature for seasons and years, from 1859 to 1867, inclusive.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859			52.8													
1860	83	15	48.3	89	42	67.7	81	7	48.5	60	—14	23.4	89	—14	47.8	103
1861	80	6	44.7	98	40	69.0	82	21	51.3	64	—14	26.5	98	—14	48.7	112
1862	89	9	45.1	95	41	69.4	86	23	51.0	65	1	34.9	95	1	48.3	94
1863	86	9	45.9	91	37	67.9	84	16	49.6	58	— 3	30.6	91	— 3	48.4	94
1864	87	5	45.7	95	38	71.1	82	18	48.8	63	—19	28.8	95	—19	48.1	114
1865	85	9	48.4	94	41	69.6	88	21	52.8	55	— 4	25.1	94	— 2	49.3	96
1866	80	9	43.2	92	41	66.9	82	19	49.3	59	—14	25.6	92	—14	46.0	106
1867	71	7	41.4	93	41	69.6	91	11	51.4	54	—14	25.1	93	—14	46.8	107

DETROIT, MICHIGAN.

Year.	Amount of rain and melted snow for months, seasons, and years, in United States inches and decimals.																
	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859	0.47	1.02	3.18	1.61	0.94							1.63	5.73				
1860	0.94	2.64	0.83	3.27	1.99	2.71	5.15	1.56	2.79	1.92	1.80	2.43	6.09	9.42	6.51	5.21	28.03
1861	1.55	1.97	5.41	3.58	1.98	3.44	2.86	3.53	7.00	3.44	1.75	1.89	10.97	9.83	12.19	5.95	38.40
1862	2.63	0.63	4.78	2.53	3.05	3.21	1.92	3.42	2.48	2.82	2.20	1.85	10.28	8.55	7.50	5.15	31.44
1863	2.01	2.08	1.82	1.40	2.67	2.50	4.20	4.22	1.12	3.11	2.91	2.33	5.89	10.92	7.14	5.94	30.37
1864	1.43	0.84	1.07	3.54	3.37	2.24	1.68	2.89	2.96	1.44	2.73	1.69	7.98	6.81	7.13	4.60	25.88
1865	0.33	0.86	2.18	1.92	1.40	1.18	3.37	2.46	2.52	3.52	0.05	1.41	5.40	7.01	6.09	2.88	21.10
1866	0.81	1.55	2.53	1.45	3.24	5.69	2.94	2.51	4.34	2.00	2.66	2.00	7.22	11.14	9.00	3.77	31.72
1867	1.74	2.72	1.22	2.19	4.38	2.54	2.32	2.27	1.82	2.12	2.16	1.39	7.79	7.13	6.10	6.46	26.87

MONROE CITY, MICHIGAN.—ALTITUDE, 567 FEET.

Year.	Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. +.28 inches.																	
	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	2.059	0.936	1.454	1.903	0.646	1.411	1.688	0.845	1.369	1.990	0.648	1.357	1.713	0.987	1.317	1.658	0.704	1.338
1861	1.980	0.690	1.443	1.814	0.785	1.345	1.947	0.870	1.407	1.752	0.852	1.303	1.759	0.711	1.335	1.574	1.160	1.370
1862	1.992	0.886	1.466	1.881	0.703	1.419	1.620	0.771	1.259	1.810	0.910	1.453	1.755	0.989	1.383	1.747	1.005	1.373
1863	1.998	0.676	1.387	2.027	0.865	1.508	1.810	0.922	1.387	1.798	0.793	1.392	1.695	0.820	1.347	1.687	0.940	1.353
1864	1.885	0.928	1.404	1.930	0.732	1.298	1.681	0.928	1.258	1.896	0.993	1.313	1.574	1.021	1.261	1.715	0.929	1.438
1865	1.901	0.898	1.407	1.949	0.924	1.455	1.750	0.643	1.329	1.838	0.892	1.383	1.687	0.912	1.321	1.510	1.077	1.375
1866	2.041	0.891	1.518	2.039	1.013	1.489	1.853	0.830	1.453	1.700	0.839	1.256	1.675	0.600	1.250	1.656	0.849	1.390
1867	1.799	0.823	1.349	1.959	0.548	1.380	1.815	0.836	1.430	1.723	0.769	1.303	1.686	0.739	1.253	1.604	0.910	1.311

MONROE CITY, MICHIGAN.—ALTITUDE 567 FEET.

Year.	Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.																	
	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	1.854	1.136	1.451	1.634	1.251	1.397	1.855	1.027	1.432	1.770	0.950	1.471	2.004	0.995	1.463	2.008	0.905	1.472
1860	1.664	0.922	1.356	1.674	1.069	1.385	1.834	1.131	1.494	1.733	0.813	1.441	1.661	0.724	1.324	2.034	0.820	1.491
1861	1.625	1.009	1.371	1.652	1.151	1.436	1.864	1.055	1.435	1.821	0.791	1.407	1.753	0.856	1.302	2.003	1.052	1.562
1862	1.690	1.087	1.347	1.717	1.141	1.427	1.767	1.049	1.485	1.841	1.118	1.456	2.059	1.119	1.512	2.101	0.955	1.460
1863	1.681	1.030	1.369	1.720	1.064	1.428	1.881	1.022	1.482	1.928	0.956	1.447	1.848	0.963	1.381	1.972	0.663	1.446
1864	1.605	1.150	1.412	1.585	0.962	1.306	1.616	1.048	1.365	1.651	0.970	1.314	1.838	0.692	1.348	2.032	0.735	1.301
1865	1.681	0.983	1.394	1.642	1.170	1.448	1.682	1.040	1.453	1.742	0.757	1.388	1.966	0.732	1.447	1.845	0.758	1.419
1866	1.604	1.078	1.374	1.700	0.975	1.341	1.664	1.012	1.394	1.875	1.033	1.464	2.059	0.862	1.393	1.943	0.661	1.390
1867	1.644	1.072	1.369	1.678	1.117	1.375	1.768	1.178	1.484	1.898	0.858	1.441	1.747	0.670	1.346	1.961	0.718	1.392

MONROE CITY, MICHIGAN. + 28 INCHES.

Year.	Maximum, minimum, and mean barometrical pressure reduced to 32° Fahr., for seasons,															Range.
	Spring.			Summer.			Autumn.			Winter.			Year.			
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							2.004	0.895	1.445							
1860	1.990	0.648	1.349	1.674	0.704	1.359	1.834	0.724	1.419	2.059	0.646	1.446	2.059	0.646	1.395	1.413
1861	1.947	0.711	1.348	1.652	1.009	1.392	1.864	0.791	1.381	2.034	0.690	1.426	2.003	0.690	1.392	1.313
1862	1.810	0.771	1.365	1.747	1.005	1.382	2.059	1.049	1.484	2.003	0.703	1.482	2.101	0.703	1.420	1.398
1863	1.810	0.703	1.375	1.720	0.940	1.383	1.928	0.956	1.437	2.101	0.676	1.452	2.027	0.663	1.410	1.364
1864	1.696	0.628	1.277	1.715	0.929	1.385	1.838	0.692	1.342	1.972	0.663	1.383	2.032	0.628	1.335	1.404
1865	1.838	0.643	1.344	1.681	0.983	1.406	1.966	0.732	1.429	2.032	0.735	1.388	1.966	0.643	1.401	1.323
1866	1.853	0.600	1.356	1.700	0.849	1.335	2.059	0 862	1.417	2.641	0.758	1.475	2.641	0.600	1.393	2.041
1867	1.815	0.730	1.329	1.678	0.910	1.359	1.898	0.670	1.424	1.959	0.548	1.373	1.961	0.548	1.371	1.413

MONROE CITY, MICHIGAN.

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	44	—15	26.1	50	— 5	26.8	66	20	39.4	65	22	44.9	82	37	60.7	82	53	68.3
1861	43	1	25.0	55	—12	30.1	64	9	33.4	74	30	46.6	79	31	53.5	87	44	68.6
1862	48	5	25.8	49	— 8	25.2	51	8	32.4	64	31	45.0	82	38	57.8	83	48	65.2
1863	52	— 7	31.3	54	— 1	28.4	65	6	32.2	76	19	45.7	89	33	61.9	97	38	67.6
1864	73	—16	25.9	52	— 8	30.8	63	4	33.1	61	28	45.1	92	36	61.7	101	38	70.0
1865	49	—45	23.3	53	— 7	28.8	75	— 7.5	38.8	76.5	24	48.7	91	31.5	60.0	96	52	75.2
1866	52	— 7	24.3	61	—19	25.8	62	7	31.8	78	22	50.5	85	29	37.1	94	47	69.3
1867	45	—17	21.8	58	— 2	33.7	59	5	32.4	75.5	26	49.0	73	30	52.9	93	41	73.1

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	90	57	73.7	85	46	72.0	73	45	60.9	74	28	47.7	62	21	40.2	53	—13	22.3
1860	83	53	71.1	89	51	71.0	82	39	60.3	73	32	52.2	58	5	37.8	40	— 1	25.6
1861	88	47	70.1	96	54	72.3	80	40	64.4	72	32	54.9	57	21	39.5	55	13	34.3
1862	93	55	74.0	89	51	74.9	84	44	66.1	80	24	53.2	66	25	41.7	59	5	34.3
1863	95	41	72.0	95	34	71.3	89	27	61.0	78	25	47.4	66	13	41.8	55	6	32.5
1864	100	47	76.5	99	44	73.6	87	36	62.5	72	25	48.7	71	12	39.2	57	— 8	27.1
1865	98	46	71.6	97	40	71.4	93	43	70.8	86	24	50.5	70	19	39.6	54	— 3	29.1
1866	103	52	78.9	92	38	69.5	92	33	61.7	85	31	55.4	67	21	40.9	53	3.5	27.7
1867	98	47	77.9	98	42	74.4	98	35	66.0	89	24	56.9	70	11.5	43.5	55	— 2	28.7

MONROE CITY, MICHIGAN.

Year.	Maximum, minimum, and mean temperature for seasons and years from 1859 to 1867, inclusive.															Range.
	Spring.			Summer.			Autumn.			Winter.			Year.			
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							74	21	49.6							
1860	82	20	48.3	89	51	70.1	82	5	50.1	50	—15	25.1	89	—15	48.7	104
1861	79	9	44.5	96	44	71.3	80	21	52.9	55	—12	26.9	96	—12	49.3	108
1862	82	8	45.1	93	48	71.4	84	25	53.7	55	— 8	28.4	93	— 8	49.6	101
1863	89	6	46.6	97	34	70.3	89	13	50.1	59	— 7	31.3	97	— 7	49.4	104
1864	92	4	46.6	101	38	73.4	87	12	50.1	73	—16	29.7	101	—16	49.5	117
1865	91	7.5	49.2	98	40	72.7	93	19	53.6	57	— 8	26.4	98	— 7	50.6	105
1866	85	7	46.5	103	38	72.6	92	21	52.7	61	—19	26.4	103	—19	49.4	122
1867	75.5	5	44.8	98	41	75.1	98	11.5	55.5	58	—17	27.7	98	—17	50.9	115

MONROE CITY, MICHIGAN.

Year.	Amount of rain and melted snow for months, seasons, and years in United States inches and decimals.																
	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859							0.66	4.14	2.10	1.81	2.42	2.73			6.33		
1860	0.93	2.40	0.65	3.79	2.65	1.86	6.39	1.69	2.43	1.94	1.29	1.77	7.09	9.94	5.66	5.66	27.75
1861	1.00	1.00	4.15	3.39	2.02	4.14	3.80	3.33	5.48	2.79	2.72	1.15	9.56	11.27	10.99	3.73	34.97
1862	2.69	1.53	4.38	2.89	3.54	2.28	1.90	2.61	2.61	3.09	2.05	3.16	10.81	6.79	7.75	5.37	32.73
1863	2.81	1.98	3.13	2.12	1.55	1.01	2.61	6.23	1.45	2.91	2.57	2.20	6.80	9.85	6.93	7.95	30.57
1864	1.42	0.75	1.43	3.72	1.98	1.54	3.10	3.35	4.19	1.75	3.78	2.17	7.13	7.99	9.72	4.37	29.18
1865	0.47	0.96	2.23	1.84	2.38	2.75	5.33	3.56	7.59	2.35	0.39	3.51	6.45	11.64	10.33	3.60	33.36
1866	1.92	1.74	3.06	0.80	3.39	4.51	2.27	1.53	5.11	2.34	2.51	1.96	7.25	8.31	9.96	7.17	31.14
1867	1.13	2.64	1.20	2.59	5.32	3.28	2.63	2.06	0.98	1.42	1.47	1.45	9.11	7.97	3.87	5.73	26.17

CLEVELAND, OHIO.—ALTITUDE 645 FEET.

Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																1.685	1.030	1.344
1860	1.954	0.950	1.371	1.788	0.760	1.384	1.622	0.817	1.286	1.894	0.547	1.282	1.614	0.927	1.248	1.571	0.628	1.261
1861	1.892	0.731	1.354	1.761	0.781	1.279	1.718	0.770	1.331	1.670	0.735	1.228	1.654	0.640	1.245	1.496	0.969	1.284
1862	1.858	0.866	1.370	1.794	0.685	1.326	1.506	0.631	1.158	1.747	0.776	1.378	1.610	0.973	1.303	1.703	0.930	1.289
1863	1.961	0.797	1.333	1.936	0.743	1.428	1.726	0.864	1.303	1.692	0.629	1.318	1.641	0.782	1.276	1.574	0.854	1.287
1864	1.821	0.838	1.341	1.665	0.695	1.223	1.647	0.535	1.187	1.593	0.908	1.249	1.523	0.929	1.192	1.645	0.867	1.367
1865	1.894	0.849	1.332	1.876	0.845	1.374	1.675	0.594	1.268	1.796	0.866	1.332	1.820	0.872	1.255	1.532	1.020	1.328
1866	2.509	0.773	1.461	1.969	0.937	1.422	1.753	0.840	1.371	1.630	0.605	1.307	1.485	0.539	1.183	1.557	0.751	1.239
1867	1.713	0.736	1.297	2.034	0.534	1.348	1.751	0.805	1.367	1.630	0.700	1.268	1.648	0.653	1.219	1.663	0.905	1.322

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	1.776	1.068	1.381	1.499	1.087	1.318	1.776	0.917	1.359	1.659	0.863	1.374	1.875	0.820	1.386	1.838	0.838	1.375
1860	1.588	0.905	1.284	1.574	1.022	1.303	1.764	1.060	1.404	1.617	0.918	1.348	1.567	0.512	1.234	1.908	0.908	1.399
1861	1.526	0.990	1.288	1.556	0.995	1.337	1.757	0.903	1.346	1.718	0.773	1.329	1.681	0.713	1.205	1.925	0.932	1.470
1862	1.663	0.907	1.276	1.646	1.070	1.360	1.602	0.937	1.393	1.682	0.913	1.367	1.942	0.896	1.343	2.016	1.031	1.409
1863	1.587	1.070	1.304	1.699	1.033	1.373	1.797	1.058	1.416	1.843	0.916	1.382	1.782	0.975	1.320	1.910	0.621	1.385
1864	1.531	1.075	1.342	1.554	0.875	1.260	1.584	0.950	1.285	1.512	0.896	1.240	1.795	0.586	1.289	1.993	0.528	1.231
1865	1.607	0.928	1.315	1.590	1.070	1.380	1.618	1.057	1.404	1.712	0.682	1.316	1.873	0.680	1.385	1.907	0.879	1.362
1866	1.581	1.018	1.335	1.635	0.932	1.300	1.664	1.009	1.342	1.778	1.111	1.424	2.022	0.808	1.364	1.866	0.615	1.350
1867	1.536	1.084	1.336	1.560	1.120	1.336	1.706	1.128	1.418	1.823	0.863	1.405	1.604	0.771	1.317	1.868	0.806	1.345

																Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859				1.776	1.030	1.347	1.875	0.863	1.373							
1860	1.894	0.547	1.272	1.588	0.628	1.282	1.764	0.512	1.328	1.954	0.700	1.377	1.954	0.512	1.317	1442
1861	1.718	0.640	1.268	1.556	0.969	1.303	1.757	0.713	1.293	1.908	0.731	1.344	1.925	0.640	1.308	1285
1862	1.747	0.631	1.279	1.703	0.907	1.308	1.942	0.896	1.367	1.925	0.685	1.389	2.016	0.631	1.331	1385
1863	1.726	0.629	1.299	1.699	0.854	1.321	1.843	0.916	1.373	2.016	0.743	1.390	1.961	0.621	1.343	1340
1864	1.647	0.535	1.209	1.645	0.867	1.323	1.795	0.586	1.271	1.910	0.621	1.316	1.993	0.528	1.267	1465
1865	1.820	0.594	1.285	1.607	0.928	1.341	1.873	0.680	1.368	1.993	0.528	1.312	1.907	0.594	1.338	1413
1866	1.753	0.539	1.287	1.635	0.751	1.291	2.022	0.808	1.377	2.509	0.773	1.415	2.509	0.539	1.341	1970
1867	1.751	0.653	1.285	1.663	0.905	1.331	1.823	0.771	1.380	2.034	0.534	1.332	2.034	0.534	1.331	1500

CLEVELAND, OHIO.

Year.	Maximum, minimum, and mean temperature for each month, from the year 1859 to 1867, inclusive.																	
	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																91	51	
1860	55	—11	28.3	68	5	29.9	70	20	41.3	75	25	46.8	85	35	63.3	83	53	67.2
1861	46	— 2	27.1	71	—12	34.1	75	9	36.5	83	26	49.0	83	31	53.4	91	39	68.2
1862	53	4	27.3	50	6	26.6	67	9	33.0	83	27	46.9	86	33	56.7	87	42	63.4
1863	55	3	32.0	52	5	29.3	64	11	32.2	76	17	43.4	88	37	60.1	91	43	66.2
1864	66	—14	26.6	60	— 8	30.3	62	12	34.7	63	30	45.4	91	32	59.5	94	42	67.7
1865	43	— 2	21.0	50	—10	26.8	76	9	39.5	79	30	51.0	91	32	59.4	91	52	74.4
1866	62	2	26.3	59	—14	27.9	67	7	33.4	84	23	51.4	89	35	56.1	93	48	68.7
1867	45	— 2	20.8	60	2	34.6	57	6	31.9	77	27	47.8	79	28	53.0	95	47	71.6

CLEVELAND, OHIO.

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	91	50	73.9	85	50	71.5	78	45	62.7	82	32	48.8	73	21	42.5	63	— 9	24.6
1860	85	51	69.7	92	41	69.6	87	37	60.7	75	37	53.2	75	5	39.7	46	6	27.5
1861	92	49	70.4	92	50	70.8	87	42	63.9	81	30	54.5	59	21	40.2	68	10	37.0
1862	93	53	72.4	93	53	72.6	88	41	65.7	85	31	54.2	72	24	39.5	59	9	34.6
1863	88	48	70.9	93	43	72.1	86	35	61.8	74	30	49.9	70	13	42.2	58	8	33.8
1864	92	55	74.9	91	52	72.4	80	47	62.8	73	33	49.7	70	15	41.7	56	2	28.1
1865	90	50	69.5	85	48	70.1	86	50	70.8	76	32	52.4	74	20	43.1	62	1	32.7
1866	97	57	76.3	92	47	66.9	85	43	61.3	75	34	52.9	62	27	42.7	57	2	26.5
1867	86	53	71.6	89	49	71.5	82	40	65.5	81	34	54.8	69	14	44.9	61	— 1	28.6

CLEVELAND, OHIO.

Maximum, minimum, and mean temperature for seasons and years from 1859 to 1867, inclusive.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859				91	50		82	21	51.3							
1860	85	20	50.5	92	47	68.8	87	5	51.2	68	-11	27.6	92	5	49.8	87
1861	83	9	46.3	92	39	69.8	87	21	52.8	71	—12	29.6	92	—12	50.4	104
1862	86	9	45.5	93	42	69.5	88	24	53.2	68	4	30.3	93	4	49.4	89
1863	88	11	45.3	93	43	69.7	86	13	51.3	59	3	32.0	93	5	49.5	88
1864	91	12	46.5	94	42	71.7	80	15	51.4	66	—14	30.2	94	—14	49.5	108
1865	91	9	50.3	91	48	71.3	86	20	55.4	56	—10	25.3	91	—10	50.9	101
1866	89	7	47.0	97	47	70.6	85	27	52.3	62	—14	29.0	97	—14	49.2	111
1867	79	6	44.2	95	47	71.6	82	14	55.1	60	— 2	27.2	95	— 2	49.7	97

Year.	Amount of rain and melted snow for months, seasons, and years, in United States inches and decimals.																
	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859							1.25	3.30	3.34	1.43	4.29	5.12			9.06		
1860	2.24	2.03	1.24	6.47	2.94	1.34	4.59	4.97	3.32	3.06	4.05	2.18	10.65	10.90	10.43	9.39	38.43
1861	2.36	1.17	3.34	4.23	3.56	1.77	1.84	3.60	3.40	3.98	4.83	1.64	11.13	7.21	12.21	5.71	36.73
1862	3.91	3.10	4.00	2.83	2.45	4.29	5.54	1.32	2.25	3.04	4.26	4.34	9.28	11.15	9.55	8.65	41.33
1863	5.44	3.35	3.20	1.50	2.97	2.66	2.02	2.32	3.13	3.13	4.36	2.52	7.67	7.00	10.62	13.13	36.60
1864	2.62	1.30	2.13	2.26	3.92	0.70	1.97	5.37	5.40	5.40	3.84	2.96	8.31	8.04	11.22	6.44	34.45
1865	2.01	1.82	3.17	3.03	2.44	2.74	3.63	1.47	5.46	2.35	0.76	3.89	8.64	7.84	8.57	6.79	32.77
1866	2.08	2.29	3.76	2.78	3.82	10.30	3.66	3.68	6.70	3.40	2.70	3.22	10.36	17.64	12.80	8.26	48.39
1867	2.92	3.45	3.07	3.25	5.02	1.84	2.65	0.75	1.43	3.58	2.72	3.26	11.34	5.24	7.73	11.59	33.94

BUFFALO, NEW YORK.—ALTITUDE 585 FEET.

Year.	Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.																	
	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	1.924	1.001	1.398	1.879	0.596	1.417	1.715	0.923	1.306	2.007	0.680	1.347	1.647	0.999	1.346	1.747	0.679	1.302
1861	2.043	0.750	1.405	1.869	0.685	1.329	1.852	0.849	1.374	1.828	0.855	1.318	1.707	0.390	1.228	1.577	1.080	1.319
1862	1.882	0.775	1.436	1.778	0.678	1.364	1.553	0.664	1.223	1.825	0.825	1.465	1.650	1.031	1.358	1.872	0.960	1.377
1863	2.117	0.654	1.361	2.146	0.827	1.520	1.871	0.870	1.371	1.767	0.536	1.389	1.680	0.797	1.345	1.556	0.813	1.334
1864	1.807	0.606	1.317	1.889	0.797	1.222	1.695	0.604	1.230	1.665	1.006	1.289	1.482	0.938	1.201	1.646	0.757	1.379
1865	1.856	0.863	1.325	1.908	0.867	1.406	1.764	0.570	1.291	1.828	0.889	1.369	1.680	0.877	1.291	1.595	1.038	1.362
1866	2.526	0.924	1.488	2.053	0.866	1.422	1.886	0.806	1.360	1.656	0.543	1.321	1.557	0.600	1.198	1.525	0.709	1.248
1867	1.672	0.724	1.267	1.945	0.601	1.350	1.831	0.820	1.377	1.671	0.716	1.261	1.754	0.782	1.214	1.577	0.886	1.329

BUFFALO, N. Y.—ALTITUDE 585 FEET.

Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	1.785	1.047	1.426	1.665	1.077	1.405	1.824	0.922	1.428	1.767	1.088	1.419	1.956	0.853	1.483	2.101	0.945	1.431
1860	1.606	1.020	1.338	1.618	1.092	1.349	1.862	1.059	1.441	1.699	0.928	1.414	1.728	0.653	1.299	1.965	0.673	1.453
1861	1.582	1.054	1.320	1.623	1.192	1.406	1.840	0.822	1.390	1.786	0.792	1.378	1.735	0.843	1.263	1.937	0.943	1.495
1862	1.731	0.990	1.319	1.741	1.141	1.400	1.742	0.872	1.469	1.735	0.965	1.393	2.145	0.884	1.401	2.117	0.886	1.422
1863	1.657	1.153	1.362	1.822	1.135	1.425	1.851	1.010	1.468	1.902	1.020	1.426	1.822	0.878	1.327	1.998	0.544	1.432
1864	1.566	1.098	1.363	1.567	0.888	1.288	1.683	0.996	1.327	1.577	0.742	1.238	1.845	0.429	1.302	1.993	0.545	1.232
1865	1.681	1.032	1.344	1.663	1.015	1.398	1.704	1.168	1.437	1.758	0.578	1.323	2.007	0.886	1.389	1.761	0.842	1.374
1866	1.620	1.085	1.336	1.635	1.065	1.288	1.668	0.912	1.357	1.911	0.958	1.437	2.019	0.638	1.347	1.982	0.493	1.345
1867	1.614	1.053	1.319	1.586	1.047	1.325	1.760	1.108	1.437	1.866	0.831	1.428	1.603	0.588	1.297	1.878	0,632	1.344

BUFFALO, N. Y. + 28 INCHES.

Maximum, minimum, and mean barometrical pressure reduced to 32° Fahr., for seasons.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							1.956	0.853	1.443							
1860	2.007	0.680	1.333	1.747	0.679	1.329	1.862	0.653	1.385	2.101	0.596	1.415	2.007	0.653	1.367	1.354
1861	1.852	0.390	1.327	1.623	1.054	1.348	1.840	0.792	1.343	2.043	0.673	1.396	2.043	0.390	1.357	1.653
1862	1.825	0.664	1.349	1.832	0.960	1.352	2.145	0.872	1.421	1.937	0.678	1.432	2.145	0.664	1.392	1.481
1863	1.871	0.536	1.368	1.822	0.813	1.374	1.902	0.878	1.407	2.146	0.654	1.434	2.146	0.536	1.397	1.610
1864	1.695	0.604	1.240	1.567	0.757	1.343	1.845	0.429	1.289	1.998	0.544	1.324	1.993	0.429	1.292	1.564
1865	1.828	0.570	1.317	1.681	1.015	1.368	2.007	0.578	1.383	1.993	0.545	1.321	2.007	0.570	1.379	1.437
1866	1.886	0.543	1.293	1.635	0.709	1.291	2.019	0.638	1.380	2.526	0.842	1.428	2.526	0.493	1.346	2.033
1867	1.831	0.716	1.284	1.614	0.886	1.324	1.866	0.558	1.387	1.982	0.493	1.391	1.945	0.601	1.329	1.344

BUFFALO, NEW YORK.

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	47	5	26.3	57	— 3	26.0	67	17	35.9	68	25	42.4	84	37	59.7	83	51	65.2
1861	42	—13	23.8	55	—22	28.6	58	— 2	30.6	73	24	44.9	79	26	51.7	81	43	65.0
1862	48	— 1	25.5	41	5	25.3	50	14	31.7	74	25	44.1	85	32	55.4	86	28	61.8
1863	55	3	31.5	49	0	26.4	51	4	28.8	72	12	43.6	86	32	55.8	89	39	62.8
1864	55	— 9	25.2	53	— 6	26.8	56	5	31.0	68	28	42.9	76	31	55.7	96	37	64.8
1865	43	—13	20.2	48	—12	22.7	65	3	35.9	70	25	44.3	78	31	54.2	90	47	68.7
1866	60	— 7	21.6	63	— 6	24.6	61	5	29.2	77	25	45.8	79	30	49.3	84	39	63.6
1867	41	0	18.9	53	5	30.9	55	7	28.5	72	25	42.0	67	23	47.7	90	40	68.3

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	88	49	70.6	87	52	70.4	75	36	60.0	69	26	46.8	63	27	41.6	50	2	23.0
1860	89	54	67.9	86	43	67.9	81	28	58.1	72	29	50.8	73	9	39.3	40	— 4	25.8
1861	84	48	68.1	87	49	69.1	78	43	61.9	73	28	52.2	55	25	38.7	61	8	34.2
1862	83	45	69.4	92	42	70.5	89	36	63.8	80	30	52.0	64	21	39.0	56	3	32.8
1863	91	51	70.5	94	39	70.3	85	31	59.6	79	24	48.5	63	19	41.8	51	3	30.2
1864	93	50	72.3	86	45	67.9	77	43	59.9	69	31	47.5	69	19	39.1	54	2	28.1
1865	85	47	66.7	86	40	68.1	90	41	68.1	69	24	47.4	66	23	39.9	57	8	31.3
1866	84	49	71.3	78	46	63.7	82	38	58.5	77	31	52.4	58	23	39.8	57	— 9	25.9
1867	85	46	70.0	87	46	70.3	80	33	61.7	77	29	48.5	65	10	41.3	54	1	24.4

BUFFALO, NEW YORK.

Maximum, minimum, and mean temperature for seasons and years from 1859 to 1867, inclusive.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							75	27	49.4							
1860	84	17	46.0	89	43	66.9	81	9	49.4	57	— 3	25.1	89	— 4	47.1	93
1861	79	— 2	42.4	87	43	64.4	78	25	51.0	55	—22	26.1	87	—22	47.4	109
1862	85	14	43.7	92	28	67.2	89	21	51.6	61	— 1	28.3	92	— 1	47.6	93
1863	86	4	42.8	94	39	67.9	85	19	50.0	56	0	30.2	94	0	47.5	94
1864	76	5	43.2	96	37	68.3	77	19	48.8	55	— 9	27.4	96	— 9	46 8	105
1865	78	3	44.8	90	40	67.8	90	23	51.8	54	—13	23.7	90	—13	47.4	103
1866	79	5	41.3	84	39	66.2	82	23	50.2	63	— 7	25.8	84	— 9	45.5	93
1867	72	7	39.4	90	40	69.5	80	10	50.5	57	— 9	25.2	90	0	46.0	90

BUFFALO, NEW YORK.

Amount of rain and melted snow for months, seasons, and years, in United States inches and decimals.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859							0.85	3.52	1.74	1.58	1.21	3.70			4.53		
1860	1.52	0.81	1.01	1.02	2.59	2.08	2.46	3.00	4.07	3.25	4.90	1.69	4.62	7.54	11.52	6.03	27.70
1861	1.55	2.37	3.30	3.18	3.12	1.22	5.00	2.87	5.08	3.60	2.20	1.55	9.60	9.09	10.88	5.61	35.04
1862	2.14	2.56	5.58	1.74	1.56	2.88	2.98	3.08	4.35	2.87	2.78	3.16	8.89	8.94	10.00	6.25	35.69
1863	2.38	2.34	2.22	1.90	1.66	1.50	4.10	2.98	1.64	3.35	2.38	1.16	5.78	8.58	7.37	7.88	27.91
1864	3.32	1.36	1.22	3.00	5.48	1.14	1.58	6.78	2.98	4.74	2.78	4.00	9.70	9.50	10.50	5.84	38.38
1865	3.17	2.02	4.60	3.90	2.94	2.56	1.48	0.82	3.52	3.16	0.66	3.04	11.44	4.86	7.34	9.19	31.87
1867	1.38	1.44	1.60	2.26	4.48	0.48	1.88	4.80	6.94	2.16	3.22	4.22	8.40	7.16	12.32	5.85	34.92
	1.77	1.36	3.44	3.36	3.78	1.56	1.98	0.44	2.14	2.08	1.30	2.42	10.58	3.98	5.52	7.35	25.73

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1860	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1861	2.466	1.123	1.763	2.273	1.068	1.668	2.310	1.210	1.744	2.322	1.237	1.679	2.121	0.936	1.645	1.904	1.353	1.664
1862	2.451	1.143	1.855	2.275	1.223	1.812	1.934	0.905	1.625	2.244	1.250	1.834	2.022	1.389	1.688	2.224	1.309	1.677
1863	2.445	0.958	1.740	2.315	1.145	1.834	2.400	1.291	1.759	2.172	1.328	1.727	1.985	1.037	1.660	1.967	1.104	1.654
1864	2.166	1.110	1.707	2.243	1.140	1.632	2.202	0.963	1.671	2.059	1.406	1.711	1.990	1.274	1.609	2.069	1.254	1.759
1865	2.250	1.195	1.722	2.283	1.218	1.796	2.171	0.828	1.659	2.208	1.116	1.744	2.144	1.198	1.692	2.041	1.400	1.758
1866	2.957	1.256	1.881	2.413	1.211	1.806	2.200	1.198	1.761	2.068	0.980	1.741	1.909	1.043	1.577	2.057	1.145	1.654
1867	2.211	1.155	1.685	2.234	1.023	17.81	2.293	1.232	1.817	2.296	1.113	1.742	2.266	1.324	1.714	2.125	1.311	1.819

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	2.064	1.410	.....	1.892	1.443	.....	2.210	1.212	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1860	1.998	1.403	1.657	1.999	1.421	1.721	2.257	1.369	1.800	2.132	1.186	1.779	2.015	0.963	1.629	2.521	1.088	1.764
1861	1.984	1.308	1.653	2.002	1.400	1.744	2.297	1.118	1.739	2.203	1.224	1.727	2.000	1.151	1.604	2.325	1.236	1.852
1862	2.052	1.318	1.670	2.183	1.422	1.753	2.067	1.236	1.804	2.107	1.117	1.737	2.617	1.208	1.744	2.502	1.246	1.757
1863	1.993	1.393	1.687	2.074	1.451	1.745	2.284	1.338	1.826	2.333	1.385	1.819	2.268	1.308	1.714	2.452	0.965	1.823
1864	1.997	1.435	1.745	1.975	1.248	1.667	2.039	1.356	1.710	2.020	1.148	1.642	2.236	0.876	1.714	2.373	1.043	1.628
1865	2.073	1.306	1.715	2.016	1.388	1.750	2.204	1.468	1.764	2.238	0.880	1.708	2.453	1.200	1.794	2.270	1.363	1.769
1866	2.088	1.380	1.773	2.061	1.435	1.721	2.130	1.382	1.824	2.355	1.375	1.901	2.499	1.035	1.848	2.486	0.978	1.765
1867	2.119	1.482	1.756	2.094	1.410	1.702	2.163	1.229	1.867	2.342	1.279	1.849	2.188	1.148	1.751	2.363	1.210	1.837

FORT NIAGARA, NEW YORK. + 28 INCHES.

Maximum, minimum, and mean barometrical pressure reduced to 32° Fahr., for seasons.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min	Mean.	Max.	Min.	Mean.	
1859																
1860																
1861							2.257	0.963	1.736							
1862	2.322	0.936	1.688	2.002	1.308	1.687	2.297	1.118	1.690	2.521	1.068	1.732	2.466	0.936	1.707	1.530
1863	2.244	0.905	1.715	2.224	1.309	1.700	2.617	1.117	1.762	2.451	1.143	1.840	2.617	0.905	1.746	1.712
1864	2.400	1.037	1.715	2.074	1.104	1.695	2.333	1.378	1.786	2.502	0.958	1.777	2.452	0.958	1.749	1.494
1865	2.202	0.963	1.164	2.069	1.248	1.724	2.336	1.148	1.689	2.432	0.965	1.656	2.373	0.963	1.683	1.310
1866	2.208	1.116	1.698	2.073	1.306	1.741	2.453	0.880	1.755	2.373	1.043	1.715	2.453	0.880	1.739	1.573
1867	2.200	0.980	1.693	2.088	1.145	1.716	2.499	1.035	1.858	2.957	1.211	1.819	2.957	0.978	1.771	1.979
	2.296	1.113	1.757	2.125	1.210	1.779	2.342	1.148	1.822	2.486	0.978	1.744	2.363	1.023	1.781	1.340

FORT NIAGARA, NEW YORK.—ALTITUDE 262 FEET.

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	53	2	27.8	60	4	26.2	63	18	36.0	56	23	39.2	78	34	53.8	84	51	63.8
1861	40	—1	23.1	54	—15	28.7	54	3	29.4	74	25	41.4	73	31	49.0	83	46	63.2
1862	47	8	25.8	42	8	25.0	46	15	31.7	75	19	40.6	81	18	53.2	80	.....	60.6
1863	56	6	31.4	50	6	25.9	49	10	28.4	71	14	40.8	82	34	53.8	89	45	61.5
1864	56	—9	25.3	51	—3	28.4	51	9	31.3	69	29	41.0	75	35	53.2	90	40	65.0
1865	43	1	21.1	45	2	24.2	55	7	33.7	67	26	43.2	79	31	52.1	88	49	67.9
1866	48	0	33.1	52	3	25.6	48	8	28.7	74	27	43.3	80	32	48.3	90	42	69.0
1867	37	3	20.5	47	4	29.5	50	7	29.0	65	26	39.1	69	27	46.9	85	45	66.4

FORT NIAGARA, NEW YORK.

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min	Mean.	Max.	Min.	Mean.
1859	88	53	69.5	82	50	69.7	74	41	59.0	73	25	46.8	65	25	39.9	60	—8	22.5
1860	80	59	67.3	88	55	67.3	76	33	58.1	69	33	49.8	70	14	39.5	43	3	25.9
1861	88	53	68.4	88	51	67.8	82	48	61.8	71	32	51.6	54	25	38.9	63	9	34.8
1862	90	.....	69.8	89	52	71.2	85	45	64.0	82	33	52.4	65	20	38.6	58	7	31.9
1863	83	54	69.1	88	48	69.9	85	40	59.2	68	27	48.3	66	22	40.2	55	14	29.8
1864	91	55	72.2	89	46	71.1	77	43	60.1	67	34	47.4	62	24	40.1	45	7	28.2
1865	84	51	67.6	89	52	67.6	86	42	65.0	70	31	48.5	67	25	41.4	57	8	31.3
1866	93	52	73.0	76	47	64.3	84	39	58.1	73	34	53.4	58	24	40.4	54	—3	26.2
1867	88	55	70.4	87	50	71.7	88	40	62.5	78	36	53.8	65	12	39.3	55	2	24.1

FORT NIAGARA, NEW YORK.

Amount of rain and melted snow for months, seasons, and years, in United States inches and decimals.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859	.....	.....	.....	.....	.....	.....	1.28	2.68	2.20	1.46	3.11	3.93	.....	.....	6.77	.....	.....
1860	1.69	2.51	1.77	1.26	1.56	1.61	3.76	3.35	1.59	1.79	3.98	3.58	4.59	8.72	7.36	8.13	28.45
1861	2.82	3.26	3.00	1.30	3.32	2.02	2.86	1.96	4.30	3.14	4.49	1.46	7.62	6.84	11.93	9.66	33.93
1862	2.14	1.91	4.14	1.18	1.14	2.23	2.28	2.35	1.94	3.66	1.84	1.92	6.46	6.86	7.44	5.51	26.73
1863	3.08	1.17	2.08	1.82	2.59	0.76	3.88	1.74	1.78	2.20	2.16	2.46	6.49	6.38	6.14	6.17	25.72
1864	2.75	0.88	2.12	3.00	4.12	0.28	3.46	3.16	1.48	5.25	1.80	2.08	5.16	7.99	5.90	6.09	24.88
1865	1.62	1.38	2.94	2.82	2.94	1.68	1.52	1.18	2.78	3.36	0.95	1.94	8.70	4.38	7.09	5.08	24.41
1866	1.03	2.20	1.90	2.22	3.06	2.05	4.53	3.32	4.56	1.12	3.38	2.12	7.18	9.90	9.06	4.47	31.49
1867	1.57	2.18	0.99	2.99	2.36	1.20	0.77	1.46	1.54	1.54	1.06	1.10	6.34	3.43	4.14	5.87	18.76

FORT NIAGARA, NEW YORK.

Maximum, minimum, and mean temperature for seasons and years from 1859 to 1867, inclusive.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							74	25	48.5							
1860	78	18	43.0	88	51	66.1	76	14	49.1	60	— 8	25.5	88	2	46.2	86
1861	73	3	39.9	88	46	66.5	82	25	50.8	54	—15	25.9	88	—15	46.5	103
1862	81	15	41.8	90	52	67.2	85	20	51.6	63	8	28.5	90	7	47.0	83
1863	82	10	41.0	88	45	66.8	85	22	49.2	58	6	29.7	88	6	46.5	82
1864	75	8	41.8	91	40	69.4	77	24	49.2	56	— 9	27.8	91	— 9	46.9	100
1865	79	7	43.0	89	49	67.7	86	25	51.6	45	1	24.5	89	1	47.0	88
1866	80	8	40.1	93	42	66.4	84	24	50.6	57	0	30.0	93	— 3	46.4	96
1867	65	7	38.3	88	45	69.5	88	12	51.9	54	— 3	25.4	88	2	45.1	86

CHARLOTTE, NEW YORK.—ALTITUDE 273 FEET.

Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 27 inches.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	2.205	1.263	1.707	2.155	0.956	1.740	2.085	1.133	1.577	2.355	1.079	1.694	1.946	1.138	1.637	1.957	0.970	1.584
1861	2.462	1.093	1.753	2.231	0.930	1.655	2.263	1.196	1.709	2.192	1.172	1.648	2.069	0.679	1.611	1.894	1.255	1.624
1862	2.357	1.005	1.779	2.183	0.945	1.713	1.957	0.968	1.579	2.193	1.140	1.817	1.958	1.260	1.669	2.183	1.275	1.641
1863	2.524	1.108	1.748	2.582	1.187	1.877	2.311	1.225	1.734	2.115	0.795	1.722	1.977	1.073	1.675	1.921	1.086	1.650
1864	2.277	0.908	1.662	2.259	1.102	1.571	2.119	1.202	1.602	2.030	1.344	1.674	1.895	1.252	1.561	2.023	1.090	1.731
1865	2.277	1.183	1.695	2.304	1.157	1.790	2.176	0.867	1.668	2.329	1.192	1.734	2.103	1.178	1.654	1.954	1.373	1.739
1866	2.989	1.216	1.857	2.498	1.250	1.811	2.175	1.139	1.708	2.067	0.895	1.700	2.034	0.989	1.558	2.031	1.153	1.638
1867	2.115	1.066	1.649	2.501	1.204	1.750	2.902	1.120	1.752	2.046	0.990	1.628	2.189	1.119	1.584	2.107	1.236	1.696

CHARLOTTE, N. Y.—ALTITUDE 273 FEET.

Year.	Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.																	
	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	2.202	1.280	1.723	1.896	1.373	1.674	2.121	1.147	1.727	2.088	1.370	1.698	2.327	1.029	1.785	2.451	1.275	1.775
1860	1.896	1.248	1.622	2.004	1.398	1.635	2.216	1.330	1.770	2.040	1.216	1.748	2.093	1.080	1.587	2.287	0.930	1.725
1861	1.903	1.367	1.625	1.947	1.431	1.727	2.180	1.282	1.714	2.165	1.102	1.702	2.038	1.165	1.589	2.298	1.249	1.792
1862	1.969	1.393	1.621	2.074	1.399	1.712	2.080	1.168	1.766	2.664	1.191	1.716	2.553	1.151	1.724	2.501	1.196	1.761
1863	1.998	1.473	1.688	2.133	1.433	1.750	2.218	1.295	1.819	2.338	1.354	1.798	2.359	1.169	1.675	2.378	0.905	1.858
1864	1.961	1.415	1.706	1.941	1.175	1.617	2.102	1.356	1.682	2.016	1.018	1.591	2.191	0.704	1.666	2.363	0.892	1.611
1865	2.128	1.356	1.699	2.062	1.382	1.762	2.116	1.585	1.801	2.125	0.767	1.681	2.419	1.160	1.756	2.156	1.263	1.768
1866	2.067	1.442	1.709	1.999	1.276	1.641	2.092	1.281	1.726	2.329	1.366	1.805	2.457	0.947	1.714	2.404	0.975	1.720
1867	2.032	1.390	1.678	1.921	1.372	1.694	2.209	1.416	1.779	2.282	1.197	1.768	2.041	1.096	1.661	2.248	0.894	1.710

CHARLOTTE, N. Y. + 28 INCHES.

Year.	Maximum, minimum, and mean barometrical pressure reduced to 32° Fahr., for seasons.															Range.
	Spring.			Summer.			Autumn.			Winter.			Year.			
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							2.327	1.029	1.736							
1860	2.335	1.079	1.621	2.004	0.970	1.614	2.206	1.080	1.701	2.451	0.956	1.741	2.335	0.930	1.665	1.405
1861	2.263	0.679	1.656	1.947	1.255	1.659	2.180	1.102	1.668	2.462	0.930	1.711	2.462	0.679	1.679	1.783
1862	2.193	0.968	1.688	2.183	1.275	1.658	2.553	1.151	1.735	2.357	0.945	1.761	2.553	0.945	1.707	1.608
1863	2.311	0.795	1.710	2.133	1.086	1.696	2.359	1.169	1.764	2.582	1.108	1.795	2.582	0.795	1.749	1.787
1864	2.119	1.202	1.612	2.023	1.090	1.685	2.191	0.704	1.646	2.378	0.905	1.704	2.363	0.704	1.641	1.659
1865	2.329	0.867	1.685	2.128	1.356	1.731	2.419	1.160	1.746	2.363	0.892	1.699	2.419	0.867	1.738	1.652
1866	2.175	0.825	1.655	2.067	1.276	1.661	2.457	0.947	1.715	2.989	1.216	1.812	2.989	0.825	1.715	2.164
1867	2.202	0.990	1.710	2.107	1.236	1.689	2.282	1.026	1.736	2.501	0.975	1.706	2.501	0.894	1.709	1.607

CHARLOTTE, NEW YORK.

Maximum, minimum, and mean temperature for each month, from the year 1859 to 1867, inclusive.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	53	5	27.7	58	2	27.3	66	10	37.2	70	23	42.9	77	41	58.0	85	49	65.8
1861	41	— 5	23.5	53	—20	29.3	61	— 2	31.6	77	20	44.6	73	24	51.0	86	39	64.3
1862	50	1	26.0	42	0	25.3	46	9	31.8	75	18	43.3	84	27	56.0	84	34	62.6
1863	56	— 5	31.9	47	—14	27.1	47	— 3	29.6	74	7	43.1	84	27	57.6	85	37	63.9
1864	64	—15	27.7	45	—12	29.6	50	2	33.1	68	21	43.4	80	26	57.4	93	32	67.3
1865	42	— 6	22.2	47	— 9	25.4	65	— 3	37.8	75	17	47.0	84	23	57.0	93	40	70.4
1866	52	—14	23.3	57	—12	27.1	59	0	30.7	77	16	48.6	84	24	51.2	93	32	66.4
1867	40	—11	21.5	54	— 4	32.3	56	— 1	32.2	70	16	44.6	69	13	50.1	89	37	69.9

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	90	51	69.3	85	51	69.0	77	41	59.3	76	27	46.9	66	27	41.4	63	— 8	23.0
1860	83	41	66.8	92	43	68.1	79	30	58.5	67	26	50.5	48	9	40.5	40	1	26.6
1861	89	43	68.2	90	42	68.7	84	36	62.1	71	23	52.3	53	19	38.7	66	3	33.5
1862	91	44	70.2	90	41	70.6	87	34	64.1	84	24	52.0	72	18	39.4	59	— 3	32.7
1863	87	46	71.7	93	35	71.6	87	27	61.0	80	17	50.5	71	11	42.4	55	— 2	30.0
1864	94	43	74.2	96	38	72.9	84	31	61.4	72	24	48.2	68	12	40.5	57	— 3	30.1
1865	88	38	68.6	96	39	70.2	91	41	69.9	72	18	49.1	73	16	41.6	66	— 3	32.5
1866	98	41	75.6	83	35	65.1	89	26	60.2	80	20	53.5	63	14	41.0	55	—22	28.3
1867	95	40	71.1	93	37	72.7	92	26	64.3	80	20	53.7	69	4	41.1	57	— 9	26.4

CHARLOTTE, NEW YORK.

Maximum, minimum, and mean temperature for seasons and years from 1859 to 1867, inclusive.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							77	27	49.2							
1860	77	10	46.1	92	41	66.9	79	9	49.9	63	— 8	26.0	92	2	47.5	9
1861	77	—2	42.4	90	39	67.1	84	19	51.0	53	—20	26.5	90	—20	47.3	110
1862	84	9	43.7	91	34	67.8	87	18	51.8	66	0	28.3	91	— 3	47.8	94
1863	84	—3	43.5	93	35	69.1	87	11	51.3	59	—14	30.6	93	—14	48.4	107
1864	80	2	44.6	96	32	71.4	84	12	50.0	64	—15	29.1	96	—15	48.8	111
1865	84	—3	47.5	96	38	69.7	91	16	53.5	57	— 9	25.9	96	— 9	49.3	115
1866	84	0	43.5	98	32	69.0	89	14	51.6	66	—14	27.6	98	—22	47.6	120
1867	70	—1	42.3	95	37	71.2	92	4	53.0	55	—22	27.4	95	—11	48.3	106

CHARLOTTE, NEW YORK.

Amount of rain and melted snow for months, seasons, and years, in United States inches and decimals.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859							2.20	4.30	2.66	1.01	2.07	3.42			5.74		
1860	0.86	1.26	1.19	1.19	1.40	2.24	4.67	1.93	3.15	3.79	2.42	1.30	3.78	8.84	9.36	5.54	25.40
1861	1.55	2.02	2.05	2.28	3.67	1.52	4.62	3.76	5.93	2.54	1.18	1.60	8.00	9.90	9.65	4.87	32.72
1862	1.71	1.70	2.74	0.98	1.53	3.26	3.17	2.02	1.75	3.19	3.22	1.97	5.25	8.45	8.16	5.01	27.25
1863	1.74	2.33	1.54	2.18	1.44	1.51	4.60	1.88	1.23	1.92	2.75	1.76	5.16	7.99	5.90	6.04	24.88
1864	2.12	1.38	3.32	2.69	6.05	0.61	1.43	4.61	1.18	5.73	2.75	3.23	12.06	6.65	9.66	5.26	35.10
1865	2.42	1.17	3.85	3.05	3.17	3.40	1.46	1.17	3.16	4.70	2.14	1.94	10.07	6.03	10.00	6.82	31.63
1866	1.68	2.28	1.66	2.32	2.99	4.10	1.02	3.93	3.97	1.34	3.35	3.59	6.97	9.05	8.66	5.90	31.23
1867	2.63	3.13	1.81	2.82	3.98	0.84	2.44	0.43	2.03	1.77	0.65	1.73	8.61	3.71	4.45	9.35	24.26

SACKETT'S HARBOR, NEW YORK.—ALTITUDE 266 FEET.

Maximum, minimum, and mean barometrical pressure for each month from the year 1859 to 1867, inclusive, reduced to 32° Fahr. + 28 inches.

Year.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	2.218	1.293	1.690	2.277	1.034	1.748	2.069	1.148	1.585	2.357	1.093	1.659	1.949	1.078	1.664	1.984	1.043	1.579
1861	2.446	1.215	1.681	2.431	0.996	1.652	2.274	1.180	1.723	2.204	1.148	1.666	2.081	0.810	1.610	1.962	1.246	1.638
1862	2.351	0.867	1.793	2.134	1.020	1.707	1.994	1.051	1.578	2.191	1.243	1.843	1.954	1.258	1.676	2.186	1.273	1.640
1863	2.503	1.114	1.759	2.555	1.080	1.873	2.290	1.161	1.730	2.118	0.823	1.708	1.948	1.080	1.661	1.911	1.106	1.628
1864	2.223	0.836	1.660	2.230	1.067	1.563	2.110	0.918	1.620	1.988	1.349	1.677	1.874	1.281	1.554	1.999	1.088	1.697
1865	2.245	1.301	1.676	2.318	1.107	1.775	2.186	0.859	1.666	2.250	1.182	1.730	2.106	1.220	1.646	1.918	1.368	1.719
1866	2.949	1.266	1.844	2.378	1.161	1.790	2.098	1.201	1.705	2.153	0.767	1.689	1.969	0.944	1.528	1.947	1.191	1.615
1867	2.160	1.016	1.630	2.500	0.941	1.759	2.245	1.085	1.769	2.016	1.112	1.625	2.191	1.039	1.546	1.941	1.249	1.684

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	2.207	1.245	1.724	1.931	1.379	1.636	2.159	1.147	1.727	2.129	1.200	1.690	2.336	1.042	1.789	2.479	1.314	1.781
1860	1.892	1.203	1.621	1.977	1.311	1.653	2.266	1.336	1.773	2.065	1.158	1.765	2.068	0.995	1.596	2.349	0.901	1.764
1861	1.905	1.315	1.631	1.994	1.432	1.737	2.174	0.888	1.721	2.196	1.142	1.724	2.076	1.135	1.592	2.291	1.239	1.825
1862	2.039	1.305	1.617	2.105	1.405	1.708	1.992	1.193	1.742	2.054	1.157	1.718	2.556	1.235	1.735	2.448	1.166	1.769
1863	1.980	1.435	1.676	2.069	1.472	1.715	2.186	1.245	1.802	2.396	1.497	1.803	2.272	1.204	1.672	2.392	0.897	1.821
1864	1.967	1.387	1.684	1.951	1.223	1.622	2.099	1.304	1.675	2.034	0.951	1.574	2.162	1.197	1.662	2.352	1.151	1.597
1865	2.043	1.357	1.667	2.043	1.340	1.772	2.133	1.564	1.788	2.162	0.999	1.675	2.054	1.105	1.635	2.191	1.130	1.751
1866	1.999	1.390	1.686	2.000	1.375	1.631	2.067	1.258	1.727	2.296	1.308	1.809				2.446	1.122	1.708
1867	2.075	1.379	1.652	1.919	1.412	1.672	2.162	1.504	1.788	2.247	1.225	1.766	2.041	1.119	1.656	2.266	1.053	1.710

SACKETT'S HARBOR, NEW YORK. + 28 INCHES.

Year.	Maximum, minimum, and mean barometrical pressure reduced to 32° Fahr. for seasons.															Range.
	Spring.			Summer.			Autumn.			Winter.			Year.			
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859							2.366	1.042	1.734							
1860	2.357	1.078	1.636	1.984	1.045	1.618	2.266	0.995	1.711	2.479	1.034	1.740	2.357	0.901	1.675	1.456
1861	2.274	0.810	1.666	1.994	1.246	1.669	2.196	0.888	1.679	2.446	0.901	1.699	2.446	0.810	1.683	1.636
1862	2.199	1.051	1.699	2.186	1.273	1.655	2.556	1.151	1.732	2.351	0.867	1.775	2.556	0.867	1.710	1.689
1863	2.290	0.823	1.699	2.069	1.106	1.673	2.326	1.204	1.759	2.555	1.080	1.800	2.555	0.823	1.737	1.732
1864	2.110	0.918	1.617	1.999	1.088	1.668	2.162	0.951	1.637	2.392	0.836	1.681	2.352	0.836	1.632	1.516
1865	2.250	0.859	1.647	2.043	1.340	1.719	2.162	0.999	1.709	2.352	1.107	1.683	2.318	0.859	1.703	1.459
1866	2.153	0.767	1.641	2.000	1.191	1.644	2.296	1.258	1.768	2.949	1.150	1.795	2.949	0.767	1.703	2.182
1867	2.245	1.039	1.647	2.075	1.249	1.669	2.247	1.119	1.737	2.500	0.941	1.699	2.500	0.941	1.688	1.559

SACKETT'S HARBOR, NEW YORK.

Year.	Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.																	
	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859																		
1860	46	—21	23.5	52	—11	23.6	61	12	34.6	66	17	42.0	76	39	60.0	80	50	61.8
1861	37	—36	18.0	50	—46	25.7	56	—13	27.3	70	18	43.0	66	26	49.4	77	44	62.0
1862	46	—13	19.8	43	—21	21.1	45	1	28.7	72	18	41.4	81	36	53.6	81	36	62.2
1863	56	—30	29.5	50	—30	23.2	57	—34	24.7	63	7	42.0	80	32	56.4	84	45	63.8
1864	50	—20	26.2	49	—24	27.2	52	0	31.9	64	28	43.5	76	33	58.9	85	42	65.8
1865	38	—15	17.5	48	—40	20.0	69	— 9	36.7	70	27	47.3	80	33	56.6	88	52	69.7
1866	58	—26	19.4	51	—20	23.3	55	2	29.7	73	22	47.2	74	31	52.2	82	61	65.6
1867	37	—32	15.3	50	— 6	29.4	47	0	29.8	69	22	43.7	70	25	48.7	86	45	67.7

SACKETT'S HARBOR NEW YORK

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	85	49	69.1	86	51	69.9	75	41	59.2	75	23	45.9	61	23	39.8	57	—21	20.4
1860	77	57	66.4	87	44	68.1	79	28	59.0	71	29	50.1	73	16	40.3	43	—15	22.5
1861	85	50	67.7	85	45	67.6	79	43	61.0	70	26	50.9	53	15	37.6	61	— 8	30.5
1862	82	50	69.6	88	43	71.1	84	40	65.0	82	27	52.4	64	10	37.9	49	—14	26.3
1863	85	52	72.4	93	45	71.6	83	33	60.7	76	23	51.0	65	14	43.1	55	— 5	26.3
1864	91	54	73.3	92	52	73.0	80	37	61.6	70	34	49.8	68	14	40.3	53	—12	28.7
1865	84	48	69.2	89	47	72.8	88	39	68.9	66	24	47.7	54	17	41.6	58	— 3	31.4
1866	88	49	74.3	81	46	66.3	85	37	60.7	77	26	53.2	.....	.....	.....	54	—30	27.3
1867	88	48	69.3	88	47	71.7	85	34	60.2	77	24	50.9	63	8	37.3	49	—19	17.6

SACKETT'S HARBOR, NEW YORK.

Maximum, minimum, and mean temperature for seasons and years from 1859 to 1867, inclusive.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859	.....	.....	.....	.....	.....	.....	75	23	48.3	.....	.....	.....	.....	.....	.....	.....
1860	76	12	55.6	87	44	66.4	79	16	49.8	57	—21	22.5	87	—21	46.3	108
1861	70	—13	39.9	85	44	65.7	79	15	49.8	50	—46	22.1	85	—46	45.0	131
1862	81	1	41.2	88	36	67.7	84	10	51.8	61	—21	23.8	88	—21	45.8	109
1863	80	—34	41.0	93	45	69.3	83	14	51.6	56	—30	26.3	93	—34	47.1	127
1864	78	0	44.8	92	42	70.7	80	14	50.6	55	—24	26.6	92	—24	48.4	116
1865	80	— 9	47.2	89	47	70.6	88	17	52.7	53	—40	22.1	89	—40	48.4	129
1867	74	2	43.0	88	46	68.7	85	24.7	.....	58	—26	24.7	88	—30	47.2	118
	70	0	40.7	88	45	69 6	85	8	49.5	54	—32	24.0	88	—32	45.1	120

Amount of rain and melted snow for months, seasons, and years at United States Military Academy.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859	.....	.....	.....	.....	.....	.....	1.62	3.28	2.64	0.98	4.16	5.18	.....	.....	7.78	.....	.....
1860	1.95	1.52	1.39	1.26	1.88	2.11	4.79	2.90	3.70	3.64	6.52	2.96	4.53	9.80	13.86	8.65	34.62
1861	2.66	5.82	2.68	2.70	4.48	2.10	6.32	4.04	5.80	4.62	3.38	1.30	9.86	12.46	13.80	11.44	45.90
1862	1.13	1.46	4.20	2.14	2.42	1.68	3.60	1.64	2.96	3.72	2.54	2.27	8.76	6.92	6.22	3.89	29.76
1863	2.96	3.08	2.07	3.34	2.02	2.34	2.56	3.44	2.40	5.44	4.70	4.50	7.43	8.34	12.54	7.61	36.13
1864	2.56	1.78	2.73	4.80	6.76	1.14	1.14	3.02	2.94	5.94	5.36	3.38	14.98	5.30	14.24	8.84	41.34
1865	1.58	1.22	3.94	3.30	2.59	4.08	2.28	0.56	1.73	4.78	2.26	2.30	9.83	6.92	8.77	6.18	30.68
1866	1.26	2.70	2.82	2.88	3.22	3.84	1.50	5.88	5.34	2.90	4.12	2.46	8.92	11.22	12.36	6.26	38.92
1867	0.86	3.00	1.56	3.30	5.60	1.02	2.10	1.34	2.84	2.08	1.78	1.52	10.66	4.46	6.70	6.32	27.90

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Jan. 1	29.713	29.516	29.411	29.547	−18	7	0	−17	8	1	−02.7	10	−18	.007	.048	.032	.029
2	29.188	29.127	29.121	29.145	−12	20	9	−11	23	10	07.3	28	−12	.013	.174	.054	.047
3	29.042	29.028	29.127	29.066	14	27	17	15	29	18	20.7	30	8	.071	.194	.083	.083
4	29.349	29.381	29.371	29.367	23	21	19	24	22	20	22.0	29	18	.112	.101	.092	.102
5	29.397	29.226	29.201	29.275	10	24	16	11	26	17	18.0	26	10	.057	.106	.078	.080
6	29.459	29.447	29.454	29.453	11	22	2	12	24	3	13.0	24	2	.061	.095	.036	.064
7	29.296	29.157	29.143	29.199	− 1	18	17	0	20	18	12.7	22	− 5	.030	.076	.083	.063
8	29.197	29.291	29.227	29.238	7	22	9	8	23	10	13.7	23	5	.048	.107	.054	.070
9	29.313	29.192	29.153	29.219	4	15	− 3	5	16	− 2	06.3	16	− 3	.041	.074	.026	.047
10	29.066	28.982	29.052	29.033	− 2	5	− 2	− 1	6	− 1	01.3	10	− 2	.028	.043	.028	.033
11	29.286	29.363	29.497	29.382	−15	9	− 7	−14	10	− 6	−03.3	12	−17	.010	.054	.020	.028
12	29.602	29.448	29.295	29.448	−13	11	15	−12	12	16	05.3	18	−12	.012	.061	.074	.049
13	29.160	29.219	29.294	29.224	−15	18	18	16	19	19	18.0	22	15	.074	.087	.087	.083
14	29.395	29.313	29.346	29.351	14	19	11	15	20	12	15.7	22	10	.071	.092	.061	.075
15	29.316	29.159	29.206	29.227	7	16	9	8	17	10	11.7	20	−12	.048	.078	.054	.060
16	29.399	29.436	29.523	29.453	−15	− 8	−18	−14	− 7	−17	−12.7	10	−18	.010	.018	.007	.012
17	29.797	29.878	29.865	29 847	−23	7	− 5	−22	8	− 4	−06.0	10	−24	.....	.048	.023	.036
18	29.676	29.543	29.489	29 569	− 1	10	13	0	11	14	08.3	15	− 6	.030	.057	.067	.051
19	29.437	29.336	29.283	29.352	10	20	19	11	21	20	17.3	23	12	.057	.096	.092	.082
20	29.139	29.076	29.091	29.102	15	20	0	16	21	1	12.7	24	0	.074	.096	.032	.067
21	29.163	29.199	29.256	29.206	− 9	17	13	− 8	18	14	08.0	20	−11	.017	.083	.067	.056
22	29.430	29.474	29.534	29.479	8	13	11	9	14	12	11.7	17	9	.051	.067	.061	.060
23	29.628	29.621	29.669	29.639	− 1	11	− 1	0	13	0	04.3	18	0	.030	.049	.030	.036
24	29.743	29.707	29.667	29.706	2	17	2	3	18	3	08.0	20	− 1	.036	.083	.036	.052
25	29.483	29.349	29.359	29 397	7	17	14	8	18	15	13.7	20	− 2	.048	.083	.071	.067
26	29.431	29.385	29.420	29.412	− 3	9	7	− 2	10	8	05.3	18	− 2	.026	.054	.048	.043
27	29.558	29.547	29.579	29.561	4	11	4	5	12	5	07.3	16	3	.041	.061	.041	.048
28	29.494	29.523	29.583	29.533	− 4	7	−10	− 3	8	− 9	−01.3	9	− 9	.025	.048	.016	.030
29	29.663	.....	29.561	29.612	−21	....	− 4	−20	....	− 3	−11.3	14	−22	.005	....	.026	.016
30	29.324	29.159	29.116	29.200	2	14	14	3	15	15	11.0	17	− 4	.036	.071	.071	.059
31	28.962	28.843	29.000	28.935	17	23	23	18	24	24	22.0	28	12	.083	.112	.119	.105
Means....	29.391	29.331	29.351	29.361	01.0	14.7	6.8	01.9	15.9	07.8	08.5	30	−24	.042	.075	.054	.056
Feb. 1	29.242	29.286	29.108	29.212	2	18	16	3	20	17	13.3	25	3	.036	.076	.078	.063
2	28.954	28.838	28.820	28.871	15	26	27	16	28	29	24.3	30	12	.074	.117	.124	.105
3	28.756	28.781	28.830	28.789	18	26	26	20	28	27	25.0	29	16	.076	.117	.129	.107
4	28.901	28.968	29.073	28.981	22	27	23	24	30	24	29.3	32	21	.093	.113	.112	.107
5	29.166	29.170	29.298	29.211	12	25	20	13	27	21	20.3	36	10	.063	.112	.096	.090
6	29.209	29.080	29.142	29.144	6	35	25	7	39	28	24.7	40	5	.046	.152	.100	.099
7	29.086	29.010	29.165	29.087	24	29	30	25	32	32	29.7	34	20	.117	.126	.144	.129
8	29.360	29.389	29.463	29.404	− 3	5	−10	− 2	6	− 9	−01.7	32	−10	.026	.023	.016	.022
9	29.507	29.476	29.594	29.526	−25	4	−11	−24	5	−10	−09.7	− 5	−25	.....	.041	.014	.028
10	29.711	29.659	29.548	29.639	−21	3	3	−20	4	4	−04.0	7	−29	.004	.038	.038	.027
11	29.436	29.451	29.437	29.441	− 8	22	− 3	− 7	24	− 2	05.0	26	− 8	.018	.095	.036	.046
12	29.183	29.096	29.213	29.164	4	25	24	5	26	25	18.7	28	− 7	.025	.123	.117	.088
13	29.349	29.435	29.697	29.494	21	26	9	22	27	10	19.7	28	8	.101	.129	.054	.095
14	29.756	29.839	29.782	29.793	− 3	11	4	− 2	12	5	05.0	17	− 8	.026	.061	.041	.043
15	29.618	29.222	28.841	29.227	7	17	23	8	19	24	17.0	25	− 3	.048	.071	.112	.077
16	28.594	28.800	29.110	28.835	15	30	21	16	32	23	23.7	35	15	.074	.144	.090	.103
17	29.337	29.311	29.293	29.314	7	17	14	8	18	15	13.7	25	5	.048	.083	.071	.067
18	29.422	29.461	29.546	29.476	10	18	9	11	20	10	13.7	25	10	.057	.076	.054	.062
19	29.535	29.447	29.433	29.472	4	7	7	5	16	18	09.7	17	3	.041	.....	.048	.045
20	29.466	29.472	29.477	29.477	9	9	9	10	19	10	10.0	15	8	.054	.054	.054	.054
21	29.511	29.556	29.632	29.567	6	15	− 6	7	16	− 5	06.0	21	− 5	.046	.074	.021	.047
22	29.534	29.510	29.027	29.357	−11	9	11	−10	10	12	04.0	15	−20	.014	.054	.061	.043
23	29.007	28.994	29.111	29.037	− 3	11	2	− 2	12	3	04.3	17	− 3	.026	.061	.036	.041
24	29.337	29.291	29.277	29.302	−16	7	− 4	−15	8	− 3	−03.3	15	−21	.009	.048	.025	.027
25	29.206	29.229	29.331	29.254	− 7	25	17	− 6	27	18	13.0	33	−11	.020	.112	.083	.072
26	29.473	29.324	29.546	29.448	− 4	18	17	− 3	20	18	11.7	24	− 4	.025	.076	.083	.061
27	29.519	29.410	29.395	29.441	11	25	19	12	29	20	20.3	30	12	.061	.089	.092	.081
28	29.411	29.313	29.166	29.297	19	19	15	20	20	17	19.0	25	10	.092	.092	.063	.082
Means....	29.307	29.279	29.298	29.295	04.0	17.8	13.2	05.0	20.5	13.2	12.9	40	−25	.049	.087	.071	.068

the northern and northwestern lakes at Superior City, Wisconsin.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	†Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.366	.777	.707	.617	SW...	SW...	NW..	2.0	2.4	2.3	2.3	S. 73 W.	0	0	0	.....	.....
a519	.598	.791	.636	SW...	SW...	Calm..	1.0	0.6	0	0.3	S. 45 W.	0	0	3	.....	.....
.823	.775	.840	.813	SE....	Calm..	Calm..	1.0	0	0	1.3	S. 45 E.	3	10	10	.....	.....
.868	.860	.850	.859	NE ...	NE ...	NE ...	4.2	8.4	15.4	8.6	N. 45 E.	10	10	10	.....	.....
.797	.754	.834	.795	SW...	SW...	Calm..	1.0	1.2	0	0.7	S. 45 W.	4	0	10	.....	.....
.804	.738	.730	.757	NW..	NW..	Calm..	1.0	1.0	0	0.7	N. 45 W.	0	0	0	.....	.....
.695	.702	.840	.746	Calm..	NW..	Calm..	0	1.0	0	0.3	N. 45 W.	3	8	10	.....	.....
.777	.864	.791	.811	NW..	NE ...	Calm..	1.0	0.6	0	0.3	N. 45 E.	6	3	10	.....	.....
.750	.829	.671	.750	NE ...	NE ...	Calm..	1.0	1.0	0	0.7	N. 45 E.	6	0	10	.....	.....
.638	.760	.638	.679	SW...	SW...	SW...	1.0	1.0	1.6	1.3	S. 45 W.	10	4	8	.....	.....
.449	.791	.611	.617	SW...	Calm..	Calm..	1.2	0	0	0.3	S. 45 W.	3	8	3	.....	.....
.498	.804	.829	.710	SW...	NE ..	NE ..	0.6	4.2	7.2	3.7	N. 45 E.	4	10	10	.....	.....
.829	.845	.845	.840	NE ...	NE ...	NE ...	1.0	8.4	3.6	4.3	N. 45 E.	10	10	10	.....	.....
.823	.850	.804	.826	NE ...	Calm..	Calm..	2.0	0	0	0.7	N. 45 E.	10	10	0	.....	.28
.777	.834	.791	.801	N.....	NE ...	SW...	1.0	0.6	2.0	0.3	West...	10	10	3	.....	.....
.449	.594	.366	.470	NW..	SW...	SW...	1.6	2.0	1.0	1.3	S. 76 W.	6	3	0	.....	.01
.....	.777	.645	.711	SW...	SW...	Calm..	1.0	12	0	0.7	S. 45 W.	0	0	0	.....	.....
.695	.797	.816	.769	NE ...	NE ...	Calm..	1.0	16	0	0.8	N. 45 E.	10	10	7	.....	.....
.797	.855	.850	.834	NE ...	NE ...	NE ...	2.0	3.0	3.6	3.0	N. 45 E.	10	10	10	.....	.....
.829	.855	.707	.797	NE ...	Calm..	NE ...	1.0	0	1.0	0.7	N. 45 E.	10	0	0	.....	.....
.577	.840	.816	.744	SW...	NE ...	Calm..	1.0	1.0	0	0.0	Calm...	3	4	8	.....	.....
.784	.816	.804	.801	NE ...	NE ...	NE ...	2.0	1.0	2.0	1.7	N. 45 E.	10	10	10	.....	.....
.695	.623	.695	.671	N.....	N.....	Calm..	1.0	0.6	0	0.5	North ..	3	0	3	.....	.....
.730	.840	.730	.767	SW...	SW...	Calm..	1.0	0.6	0	0.6	S. 45 W.	10	10	10	.....	.....
.777	.840	.823	.813	NW..	N.....	NW..	0.6	2.0	3.6	1.7	N. 29 W.	10	10	10	.....	.....
.671	.791	.777	.746	NW..	NW..	NW..	1.0	2.0	3.0	2.0	N. 45 W.	10	10	8	.....	.....
.750	.804	.750	.768	NW..	NW..	NW..	2.0	1.0	0.6	1.3	N. 45 W.	10	10	10	.....	.....
.658	.777	.557	.664	NW..	NW..	NW..	2.4	3.0	2.0	2.7	N. 45 W.	3	0	0	.....	.....
.303	.....	.671	.487	NW..	NW..	Calm..	1.0	1.0	0	0.7	N. 45 W.	0	0	0	.....	.....
.730	.823	.823	.792	NW..	NW..	NW..	2.0	4.2	3.6	2.7	N. 45 W.	10	10	10	.....	.....
.840	.868	.868	.859	SW...	SW...	SW...	1.0	1.0	4.2	2.0	S. 45 W.	10	10	10	.....	.....
.690	.789	.751	.740	.....	.....	.....	....	....	....	0.7	N. 5 E..	6.3	5.8	6.2	....	.29
.730	.702	.834	.755	SW...	SW...	NE ...	1.0	1.0	1.0	0.3	S. 45 W.	8	3	10	.....	.28
.829	.768	.775	.791	Calm..	NE ...	NE...	0	1.0	1.0	0.7	S. 45 E.	10	10	10	.....	.....
.702	.768	.880	.783	Calm..	NE ...	NE ...	0	1.0	0.6	0.6	N. 45 E.	10	10	10	.....	.....
.738	.675	.868	.760	Calm..	SE....	Calm..	0	2.0	0	0.7	S. 45 E.	10	10	10	.....	.....
.810	.761	.855	.809	NW..	NW..	NW..	1.0	4.2	1.0	2.0	N. 45 W.	0	10	10	.....	.....
.769	.636	.655	.687	Calm..	SW...	Calm..	0	3.0	0	1.0	S. 45 W.	3	0	10	.....	.....
.872	.694	.794	.787	Calm..	NE ...	Calm..	0	2.0	0	0.7	N. 45 E.	10	10	10	.....	.....
.671	.645	.557	.624	NW..	NW..	NW..	2.4	4.2	2.0	2.6	N. 45 W.	8	0	0	.....	.....
.....	.750	.539	.645	SW...	NW..	NW..	1.0	1.0	1.0	1.0	N. 78 W.	0	0	0	.....	.....
.269	.740	.740	.583	SW...	NE ...	Calm..	1.0	1.0	0	0.0	Calm...	0	8	10	.....	.....
.594	.738	.671	.668	SW...	SW...	Calm..	1.0	0.6	0	0.6	S. 45 W.	0	0	0	.....	.20
.658	.876	.872	.802	E.....	E.....	Calm..	1.0	0.6	0	0.5	East ...	10	10	8	.....	.....
.860	.880	.791	.844	NE ...	NE ...	NW..	2.0	1.0	2.0	1.3	N. 10 E.	10	8	0	.....	.....
.671	.804	.750	.742	E.....	NW..	Calm..	1.0	1.0	0	0.3	N. 19 E.	10	10	0	.....	.....
.777	.692	.868	.779	NE ...	NE ...	NE ...	2.0	8.4	6.0	5.5	N. 45 E.	10	10	10	.....	.....
.829	.794	.730	.784	NW..	NW..	NW..	2.0	4.2	3.6	3.0	N. 45 W.	10	10	0	.....	.88
.777	.840	.823	.813	NW..	NW..	NW..	0.6	1.0	1.0	0.7	N. 45 W.	10	8	6	.....	.....
.797	.702	.791	.763	NW..	NW..	NE ...	1.0	1.0	3.0	1.3	N. 11 E.	10	10	8	.....	.....
.750	.....	.777	.764	NE ...	NE ...	NE ...	1.2	8.4	6.0	5.3	N. 45 E.	10	10	10	.....	.....
.791	.791	.791	.791	NE ...	NE ...	NE ...	2.0	6.0	3.6	4.0	N. 45 E.	10	10	10	.....	.....
.769	.829	.627	.742	Calm..	NW..	Calm..	0	0.5	0	0.2	N. 45 E.	10	10	0	.....	.15
.539	.791	.804	.711	NE ...	NE ...	Calm..	1.0	6.0	0	2.3	N. 45 E.	10	10	10	.....	.....
.671	.804	.730	.735	NW..	NW..	NW..	1.0	0.6	2.0	1.2	N. 45 W.	10	8	3	.....	.....
.423	.777	.658	.619	NW..	NE ...	Calm..	1.0	1.0	0	0.5	North ..	0	0	0	.....	.....
.611	.761	.840	.737	Calm..	SW...	SW...	0	2.0	1.0	1.0	S. 45 W.	8	9	0	.....	.....
.658	.702	.840	.733	NE ...	NE ...	NE ...	0.6	1.0	2.0	1.2	N. 45 E.	10	3	10	.....	.....
.804	.556	.850	.737	NE ...	NE ...	Calm..	2.0	1.0	0	1.0	N. 45 E.	10	8	10	.....	.....
.850	.850	.671	.790	NE ...	NE ...	NE ...	3.6	8.4	20.0	10.7	N. 45 E.	10	10	10	.....	.....
.712	.745	.788	.727	.....	.....	.....	....	....	....	1.2	N. 24 E.	7.8	7.3	6.3	.....	1.51

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.																	
March 1	28.817	28.893	29.021	28.910	16	20	– 1	17	23	0	13.3	25	0	.078	.074	.030	.061
2	29.459	29.430	29.409	29.433	–12	13	– 8	–11	14	– 7	–01.3	22	–12	.013	.012	.018	.014
3	29.350	29.212	29.187	29.250	– 6	16	8	– 5	17	9	07.0	20	– 8	.021	.078	.018	.042
4	29.348	29.347	29.423	29.373	0	18	1	1	19	2	07.3	22	– 1	.032	.087	.034	.051
5	29.633	29.646	29.623	29.634	0	18	11	11	20	12	11.0	28	– 1	.032	.076	.061	.056
6	29.419	29.335	29.455	29.403	14	28	18	15	30	20	25.0	31	10	.071	.130	.076	.092
7	29.553	29.611	29.686	29.617	– 2	20	4	– 1	22	5	08.7	25	– 3	.028	.085	.041	.051
8	29.764	29.667	29.641	29.691	–10	20	1	– 9	25	2	06.0	28	–10	.016	.050	.034	.033
9	29.523	29.413	29.346	29.427	– 1	18	15	0	20	16	12.0	22	– 6	.030	.076	.074	.060
10	29.039	29.013	29.273	29.108	19	29	14	20	33	15	29.3	33	13	.092	.114	.071	.092
11	29.576	29.557	29.561	29.565	– 9	20	9	– 8	23	10	08.3	26	–11	.017	.074	.054	.048
12	29.571	29.516	29.497	29.528	5	17	– 1	6	18	0	08.0	23	– 1	.043	.083	.030	.052
13	29.542	29.473	29.522	29.512	–21	9	– 4	–20	10	– 3	–04.3	13	–24	.004	.054	.025	.028
14	29.535	29.427	29.461	29.474	–16	18	1	–15	19	2	02.0	20	–20	.009	.087	.034	.043
15	29.479	29.414	29.466	29.453	–11	20	3	–10	22	4	05.3	25	14	.014	.085	.038	.046
16	29.486	29.323	29.324	29.378	– 6	18	0	– 5	19	1	05.0	20	–11	.021	.087	.032	.047
17	29.276	29.172	29.192	29.213	–15	14	3	–14	15	4	01.7	19	–19	.010	.071	.038	.040
18	29.304	29.197	29.151	29.217	–16	14	7	–15	15	8	02.7	20	–18	.009	.071	.048	.043
19	29.518	29.515	29.595	29.543	4	24	14	5	25	15	15.0	26	– 2	.041	.117	.071	.076
20	29.617	29.557	29.492	29.555	–17	25	24	18	29	26	24.3	30	14	.063	.089	.105	.083
21	29.405	29.360	29.387	29.384	24	28	23	25	30	24	26.3	33	23	.117	.130	.119	.130
22	29.433	29.406	29.378	29.406	23	30	27	24	35	28	29.0	38	20	.112	.109	.136	.119
23	29.390	29.402	29.498	29.430	23	30	10	24	32	11	22.3	33	10	.112	.144	.057	.104
24	29.540	29.531	29.541	29.537	9	20	10	10	22	11	14.3	25	– 4	.054	.085	.057	.065
25	29.676	29.624	29.603	29.601	– 4	25	13	– 3	31	14	08.0	31	– 6	.025	.066	.067	.053
26	29.579	29.483	29.398	29.487	17	22	19	18	23	20	20.3	25	10	.083	.107	.092	.094
27	29.499	29.458	29.480	29.479	14	30	14	15	33	15	21.0	36	11	.071	.132	.071	.091
28	29.521	29.458	29.476	29.485	15	40	28	16	46	30	30.7	48	9	.074	.169	.130	.124
29	29.460	29.323	29.327	29.370	24	45	35	26	52	40	36.0	54	23	.106	.207	.139	.151
30	29.360	29.248	29.217	29.275	27	50	32	29	50	36	38.3	57	25	.124	.361	.129	.205
31	29.177	28.964	28.877	29.006	28	45	35	32	56	39	42.3	60	25	.108	.155	.152	.138
Means....	29.447	29.386	29.403	29.412	04.5	24.0	11.8	05.7	26.7	13.2	15.2	60	–24	.053	.105	.067	.075
April 1	28.910	28.995	29.145	29.017	27	38	33	28	44	35	35.7	47	21	.136	.151	.162	.150
2	29.330	29.304	29.287	29.307	20	35	30	23	36	32	30.3	40	19	.074	.191	.144	.136
3	29.305	29.264	29.354	29.308	25	35	30	28	41	32	33.7	45	25	.100	.126	.144	.123
4	29.382	29.419	29.415	29.405	29	33	26	30	34	27	30.3	35	25	.149	.175	.129	.151
5	29.403	29.291	29.071	29.255	26	45	35	28	52	37	39.0	55	17	.117	.207	.178	.167
6	29.007	28.932	29.039	28.993	32	40	30	34	48	33	38.3	51	30	.155	.143	.139	.143
7	29.085	29.185	29.276	29.182	28	45	30	30	51	33	38.0	52	25	.130	.220	.132	.161
8	29.525	29.519	29.534	29.526	24	40	30	25	46	32	34.3	51	20	.117	.169	.144	.143
9	29.530	29.358	29.340	29.409	28	50	35	30	57	38	41.7	58	23	.130	.208	.165	.168
10	29.362	29.398	29.416	29.392	33	35	24	35	36	25	32.0	46	25	.162	.191	.117	.157
11	29.330	29.262	29.152	29.228	29	58	43	30	62	44	45.3	63	30	.149	.429	.264	.281
12	29.100	28.953	29.005	29.019	33	38	31	34	40	33	35.7	46	25	.175	.203	.151	.176
13	29.045	29.039	29.094	29.059	34	40	35	35	42	38	38.3	42	28	.183	.221	.165	.190
14	29.080	29.082	29.060	29.067	35	39	35	36	40	36	37.3	41	29	.191	.225	.191	.202
15	29.065	29.088	29.197	29.117	43	52	38	44	56	40	46.7	61	36	.264	.335	.203	.267
16	29.315	29.328	29.412	29.352	43	49	40	44	62	45	50.3	65	32	.264	.176	.182	.207
17	29.552	29.513	29.473	29.513	38	44	36	40	50	38	42.7	59	30	.203	.209	.186	.198
18	29.404	29.178	29.144	29.242	34	44	40	35	45	42	40.7	47	34	.183	.275	.221	.226
19	29.276	29.152	29.043	29.157	40	53	43	42	64	45	50.3	68	35	.221	.272	.251	.248
20	29.169	29.223	29.249	29.214	39	47	34	40	52	36	42.7	55	35	.225	.257	.170	.217
21	29.197	29.175	29.195	29.189	30	30	31	32	32	32	32.0	41	30	.144	.144	.162	.150
22	29.243	29.292	29.330	29.288	29	30	29	30	35	30	31.7	58	29	.149	.109	.149	.136
23	29.415	29.386	29.369	29.390	29	40	33	30	42	35	35.7	44	20	.149	.221	.162	.177
24	29.392	29.278	29.283	29.318	35	48	50	37	52	52	47.0	52	28	.178	.288	.334	.267
25	29.214	29.131	.....	29.173	33	50	....	35	52	....	43.5	....	....	.162	.334	.....	.248
26	.....	29.200	29.345	29.273	....	33	25	....	34	26	30.0	52	25	.....	.175	.123	.149
27	29.418	29.268	29.129	29.272	22	40	35	23	45	40	36.0	49	16	.107	.182	.139	.142
28	28.945	28.839	28.798	28.861	40	49	50	43	60	55	52.7	60	36	.208	.303	.295	.235
29	28.725	28.856	29.239	28.940	46	40	35	48	45	36	43.0	57	35	.284	.189	.191	.218
30	29.348	29.254	.....	29.201	33	35	....	35	37	....	36.0	....	....	.162	.178	.....	.170
Means....	29.244	29.203	29.228	29.222	32.3	41.8	34.5	33.8	44.7	36.7	39.0	68	16	.168	.215	.178	.187

the northern and northwestern lakes at Superior City, Wisconsin.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
.834	.598	.695	.709	SW..	SW..	SW..	1.0	4.2	6.0	3.7	S. 45 W.	10	0	0	.....	.10
.519	.498	.594	.537	SW..	SW..	Calm..	1.0	1.0	0	0.7	S. 45 W.	0	0	0	.....	.....
.627	.834	.594	.685	Calm..	NW...	Calm..	0	1.0	0	0.3	N. 45 W.	10	3	10	.....	.....
.707	.845	.718	.757	SW..	SW..	Calm..	1.0	3.0	0	1.3	S. 45 W.	0	4	0	.....	.....
.707	.702	.804	.771	NW...	SW..	Calm..	3.0	4.2	0	1.7	S. 83 W.	0	0	10	.....	.....
.823	.782	.702	.769	SW..	SW..	SW..	2.0	6.0	3.0	3.7	S. 45 W.	10	10	8	.....	.....
.683	.721	.750	.718	SW..	SW..	Calm..	1.0	0.6	0	0.6	S. 45 W.	1	0	3	.....	.....
.557	.378	.718	.551	SW..	NE...	Calm..	1.0	1.0	0	0.0	Calm...	0	0	0	.....	.....
.695	.702	.829	.742	SW..	NE...	NE...	0.6	0.6	1.0	0.3	N. 45 E.	10	8	10	.....	.....
.850	.606	.823	.760	Calm..	SW..	NW...	0	3.0	2.4	1.3	S. 80 W.	10	6	0	.....	.....
.577	.598	.791	.655	SW..	NE...	Calm..	1.0	1.0	0	0.0	Calm...	0	0	3	.....	.16
.760	.840	.695	.765	NE...	NE...	NW...	1.0	1.6	3.0	1.3	N. 12 W.	10	10	0	.....	.....
.269	.791	.658	.573	NW...	NW...	NW...	3.0	4.2	5.4	4.0	N. 45 W.	0	0	0	.....	.02
.423	.845	.718	.662	SW..	SW..	SW..	4.2	6.0	1.0	3.7	S. 45 W.	0	0	0	.....	.....
.539	.721	.740	.667	SW..	SW..	Calm..	2.4	3.6	0	2.0	S. 45 W.	0	0	0	.....	.....
.627	.845	.707	.726	SW..	SW..	SW..	1.0	4.2	5.4	3.7	S. 45 W.	0	8	3	.....	.....
.449	.823	.740	.671	SW..	SW..	Calm..	0.6	3.0	0	1.3	S. 45 W.	0	0	0	.....	.....
.423	.823	.777	.674	Calm..	NE...	Calm..	0	0.6	0	0.3	N. 45 E.	0	8	3	.....	.....
.750	.872	.823	.815	Calm..	NE...	Calm..	0	1.6	0	0.6	N. 45 E.	0	0	0	.....	.....
.840	.556	.754	.717	Calm..	NE...	Calm..	0	2.0	0	0.7	N. 45 E.	10	10	8	.....	.....
.872	.782	.868	.841	Calm..	NE...	Calm..	0	3.0	0	1.0	N. 45 E.	10	10	10	.....	.....
.868	.537	.883	.829	Calm..	NE...	Calm..	0	0.6	0	0.3	N. 45 E.	10	10	10	.....	.06
.868	.794	.797	.820	NW...	NW...	NW...	2.4	1.0	1.2	1.6	N. 45 W.	10	10	0	.....	.....
.791	.721	.797	.770	E.....	E.....	Calm..	1.0	1.2	0	4.3	East...	0	0	0	.....	.....
.658	.380	.816	.618	SW..	NE...	Calm..	1.0	0.9	0	0.2	S. 45 W.	0	0	4	.....	.....
.840	.864	.850	.851	NE...	NE...	NE...	1.0	7.2	3.0	3.7	N. 45 E.	10	10	10	.....	.....
.823	.703	.823	.783	Calm..	NE...	Calm..	0	1.6	0	0.6	N. 45 E.	0	0	0	.....	.....
.829	.543	.782	.718	SW..	SW..	Calm..	1.0	2.0	0	1.0	S. 45 W.	0	0	3	.....	.....
.754	.535	.557	.615	SW..	SW..	SW..	2.0	3.6	4.2	3.0	S. 45 W.	3	0	0	.....	.....
.775	1.000	.610	.795	SW..	Calm..	Calm..	1.6	0	0	0.6	S. 45 W.	0	0	3	.....	.....
.594	.346	.636	.525	SW..	SW..	SW..	1.0	2.0	3.0	2.0	S. 45 W.	0	0	0	.....	.....
.688	.696	.743	.709	.....	.....	.....	....	....	....	0.6	S. 62 W.	3.6	3.5	3.2	.....	.34
.883	.522	.797	.734	N.....	NW...	S.....	1.0	1.2	2.0	4.3	N. 49 W.	8	3	2	.....	.....
.598	.900	.794	.764	SW..	NE...	NE...	1.0	1.0	3.0	1.0	N. 45 E.	0	8	10	.....	.....
.655	.488	.794	.646	NE...	N.....	Calm..	9	1.0	0	0.7	N. 23 E.	0	3	10	.....	.....
.890	.895	.880	.888	N.....	N.....	Calm..	1.0	2.0	0	1.0	North..	10	8	7	.....	.....
.768	.535	.807	.703	NE...	SW..	SW..	1.0	2.4	1.0	0.6	S. 45 W.	0	0	2	.....	.....
.792	.426	.703	.640	SW..	SW..	NW...	4.2	5.4	1.2	5.3	N. 85 W.	5	4	2	.....	.....
.782	.590	.703	.692	Calm..	SW..	Calm..	0	4.2	0	1.3	S. 45 W.	0	0	0	.....	.....
.872	.543	.794	.736	NW...	NW...	Calm..	1.0	2.0	0	1.0	N. 45 W.	0	0	0	.....	.....
.782	.577	.719	.693	NW...	NW...	NW...	2.0	3.6	1.0	2.2	N. 45 W.	0	0	0	.....	.....
.797	.900	.872	.856	NW...	NE...	NE...	6	2.0	6	1.0	N. 24 E.	0	0	0	.....	.....
.890	.772	.918	.860	SW..	SW..	Calm..	3.0	4.0	0	2.3	S. 45 W.	0	0	0	.....	.....
.895	.820	.800	.838	NE...	NE...	NE...	1.0	2.4	6	1.3	N. 45 E.	0	0	0	.....	.....
.898	.829	.719	.815	NE...	NE...	Calm..	9	2.4	0	1.0	N. 45 E.	0	8	10	.....	.....
.900	.910	.900	.903	Calm..	Calm..	NE...	0	0	1.0	0.3	N. 45 E.	10	10	10	.....	.....
.918	.747	.820	.828	Calm..	NE...	Calm..	0	4	0	1.3	N. 45 E.	8	3	0	.....	.47
.918	.317	.607	.614	W....	W....	W....	2.0	5.4	9	5.5	West...	0	0	0	.....	.....
.820	.581	.811	.737	W....	NE...	NE...	1.0	6	1.0	0.3	N 8 E..	0	3	7	.....	.....
.898	.920	.829	.882	NE...	SW..	SW..	1.2	3.0	3.6	1.8	N. 45 E.	10	10	0	.....	.....
.829	.441	.840	.703	SW..	SW..	SW..	2.0	6.0	1.0	3.0	S. 45 W.	0	3	4	.....	.08
.910	.660	.802	.791	NW...	NW...	N.....	3.0	1.0	6	3.0	N. 18 W.	4	0	10	.....	.10
.794	.794	.896	.828	E.....	NE...	NE...	1.0	3.0	4.2	2.7	N. 51 E.	10	8	10	.....	.....
.890	.537	.890	.772	NE...	NE...	Calm..	3.0	1.0	0	1.3	N. 45 E.	10	3	10	.....	.....
.890	.829	.797	.839	Calm..	NE...	Calm..	0	1.0	0	0.3	N. 45 E.	0	4	4	.....	.....
.807	.727	.861	.798	SW..	W....	Calm..	1.0	2.4	0	1.3	S. 80 W.	0	5	10	.....	.....
.797	.861	.....	.829	SW..	W....	Calm..	2.0	4.2	....	2.0	S. 76 W.	6	5	....	.....	.....
.....	.895	.876	.886	.....	NW...	NW...	....	2.0	1.0	1.0	N. 45 W.	....	7	3	.....	.....
.864	.607	.557	.676	SW..	SW..	SW..	1.0	3.0	3.0	2.3	S. 45 W.	0	0	6	.....	.54
.750	.392	.681	.608	S.....	SSW..	SSW..	4.2	8.4	15.4	9.3	S. 19 W.	0	5	10	.....	.....
.850	.607	.900	.786	SW..	NE...	N.....	1.0	2.0	2.0	1.0	N. 13 E.	6	10	8	.....	.10
.797	.807	.....	.802	NE...	NE...	.....	1.0	6.0	....	2.3	N. 45 E.	0	7	....	.....	.20
.829	.681	.799	.705	.....	.....	.....	....	....	....	0.7	N. 74 W.	3.0	3.9	4.8	.....	1.49

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
May 1	29.498	29.498	29.538	29.511	29	35	27	39	30	28	32.3	40	23	.149	.152	.136	.145
2	29.616	29.504	29.441	29.520	25	40	32	27	47	33	35.7	47	15	.112	.156	.168	.145
3	29.358	29.097	29.015	29.157	34	40	33	35	41	35	37.0	46	25	.183	.235	.162	.193
4	28.920	28.899	28.892	28.904	33	40	35	34	43	37	38.0	47	35	.175	.208	.178	.187
5	29.052	29.196	29.304	29.184	38	35	31	40	40	32	37.3	45	30	.203	.139	.162	.168
6	29.335	29.337	29.380	29.351	32	37	33	33	38	35	35.3	40	26	.168	.207	.162	.179
7	29.443	29.306	29.294	29.348	32	38	34	33	40	35	36.0	42	20	.168	.203	.183	.185
8	29.212	29.142	29.135	29.163	33	34	33	34	35	34	34.3	37	32	.175	.183	.175	.178
9	29.110	29.152	29.236	29.166	33	35	33	34	36	34	34.7	38	32	.175	.191	.175	.180
10	29.314	29.340	29.353	29.336	38	48	38	40	52	41	44.3	56	33	.203	.282	.190	.225
11	29.391	29.418	29.454	29.421	44	44	45	45	45	48	46.0	56	32	.275	.275	.260	.270
12	29.426	29.371	29.336	29.378	38	40	40	40	42	41	41.0	43	35	.203	.221	.235	.220
13	29.222	29.195	29.179	29.199	40	45	32	41	48	33	40.7	48	32	.235	.260	.168	.221
14	29.015	29.009	29.087	29.037	37	39	37	38	40	38	38.7	43	25	.207	.225	.207	.213
15	29.072	29.178	29.201	29.150	41	43	41	42	45	42	43.0	47	28	.244	.251	.244	.246
16	29.224	29.258	29.295	29.259	38	45	40	39	47	41	42.3	48	36	.216	.273	.235	.241
17	29.426	29.461	29.556	29.481	40	35	40	43	58	41	47.3	53	39	.208	.393	.235	.279
18	29.576	29.474	29.456	29.502	41	40	41	42	42	42	42.0	58	40	.244	.291	.244	.260
19	29.392	29.379	29.344	29.372	39	40	41	40	41	42	41.0	46	40	.225	.235	.245	.235
20	29.354	29.339	29.342	29.345	40	41	40	41	43	41	41.7	57	41	.235	.231	.235	.234
21	29.314	29.291	29.266	29.290	42	46	41	44	47	42	44.3	44	40	.241	.297	.244	.261
22	29.256	29.246	29.231	29.244	44	41	39	49	42	40	43.7	41	41	.223	.242	.225	.231
23	29.170	29.072	29.034	29.092	41	51	43	42	61	44	49.0	45	41	.244	.244	.264	.250
24	28.949	28.918	29.022	28.963	45	51	43	47	53	44	48.0	44	41	.273	.348	.264	.295
25	29.050	29.087	29.182	29.106	44	50	38	45	52	39	45.3	38	37	.275	.334	.216	.275
26	29.256	29.281	29.329	29.289	45	44	42	48	46	43	45.7	45	40	.260	.262	.254	.258
27	29.419	29.391	29.401	29.404	42	42	43	44	43	44	43.7	43	42	.241	.254	.264	.253
28	29.346	29.324	29.282	29.317	42	43	40	44	44	41	43.0	42	39	.241	.264	.235	.247
29	29.316	29.405	29.287	29.336	49	60	52	50	69	59	59.3	61	57	.335	.398	.296	.343
30	29.483	29.521	29.493	29.499	46	49	44	47	51	46	48.0	48	44	.297	.321	.262	.293
31	29.478	29.391	29.358	29.409	44	43	45	45	45	47	45.7	48	45	.275	.251	.273	.266
Means....	29.290	29.273	29.281	29.279	39.0	43.0	39.9	40.5	45.6	40.1	42.1	61	15	.223	.263	.219	.235
June 1	29.281	29.238	29.035	29.185	44	44	45	46	45	46	45.7	46	43	.262	.275	.286	.274
2	28.840	28.876	28.916	28.877	53	53	50	54	55	51	53.3	51	51	.389	.376	.348	.371
3	28.992	28.921	29.095	29.003	52	67	62	55	77	68	66.7	68	67	.349	.527	.476	.451
4	29.327	29.417	29.286	29.343	51	50	46	53	51	47	50.3	47	44	.348	.348	.297	.331
5	29.203	29.081	29.042	29.109	49	51	48	51	54	49	51.3	49	47	.321	.335	.322	.326
6	28.984	29.052	29.147	29.061	46	47	46	47	48	47	47.3	47	44	.297	.310	.297	.301
7	29.195	29.236	29.329	29.253	43	44	43	44	45	44	44.3	44	41	.264	.275	.264	.268
8	29.346	29.351	29.368	29.355	44	46	46	45	47	47	46.3	47	44	.275	.297	.297	.290
9	29.343	29.245	29.263	29.284	48	50	47	49	51	48	49.3	47	46	.322	.348	.310	.327
10	29.268	29.111	29.232	29.204	57	64	59	58	74	61	64.3	61	59	.452	.462	.473	.462
11	29.111	29.055	29.163	29.110	61	64	58	65	83	62	70.0	64	62	.483	.342	.439	.421
12	29.324	29.324	29.367	29.338	58	57	49	61	61	50	57.3	50	48	.442	.412	.335	.397
13	29.310	29.126	29.162	29.199	57	52	51	58	53	52	54.3	52	47	.452	.375	.361	.396
14	29.173	29.159	29.130	29.154	59	67	63	61	78	67	68.7	67	65	.473	.514	.522	.503
15	29.172	29.204	29.289	29.222	58	64	57	63	69	60	64.0	60	58	.416	.529	.426	.457
16	29.392	29.285	29.228	29.302	54	47	47	55	48	48	50.3	48	44	.404	.310	.310	.341
17	29.124	29.115	29.315	29.185	50	59	54	51	61	55	55.7	56	54	.348	.473	.404	.408
18	29.392	29.464	29.444	29.433	66	65	62	73	75	69	72.3	53	53	.545	.483	.462	.497
19	29.429	29.434	29.435	29.433	62	57	47	65	58	48	57.0	47	43	.516	.452	.310	.426
20	29.426	29.406	29.391	29.408	46	46	46	47	47	47	47.0	46	43	.297	.297	.297	.297
21	29.278	29.250	29.271	29.266	47	50	51	48	51	52	50.3	52	48	.310	.348	.334	.331
22	29.335	29.266	29.271	29.291	65	69	55	66	73	56	65.0	56	53	.604	.601	.480	.562
23	29.275	29.152	29.166	29.198	50	54	50	51	55	51	52.3	52	47	.348	.404	.348	.367
24	28.974	28.926	29.006	28.969	48	50	50	49	51	51	50.7	50	47	.322	.348	.348	.339
25	28.989	28.948	29.006	28.981	60	67	51	61	71	52	61.3	52	49	.505	.608	.361	.491
26	28.962	28.940	29.036	28.979	54	55	55	55	56	56	55.7	54	52	.404	.490	.490	.461
27	29.265	29.404	29.329	29.333	57	61	57	60	67	60	62.3	60	60	.436	.457	.436	.443
28	29.442	29.386	29.304	29.377	58	65	63	61	73	65	66.3	65	64	.443	.510	.549	.501
29	29.091	28.942	28.965	28.999	60	80	76	62	93	80	78.3	82	79	.491	.647	.843	.727
30	29.198	29.203	29.261	29.221	63	70	60	68	77	63	69.3	65	62	.509	.639	.478	.542
Means....	29.215	29.184	29.208	29.202	54.0	57.2	53.1	56.1	61.6	55.1	57.6	82	41	.400	.431	.392	.408

the northern and northwestern lakes at Superior City, Wisconsin.

VAPOR.				WIND.								Amount of cloudiness. (=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.890	.636	.883	.803	NW...	NW...	NW...	1.0	4.2	6.0	3.7	N. 45 W.	3	4	0	.....	.04
.761	.483	.893	.712	N.....	SW...	Calm..	1.0	3.0	0.0	1.0	S. 70 W.	0	0	4	.....	.....
.898	.912	.297	.702	NE....	NE....	NE....	0.6	4.2	7.2	4.0	N. 45 E.	10	10	10	.....	.....
.895	.750	.807	.817	NE....	SW...	NE....	2.0	2.0	0.6	0.3	N. 45 E.	10	6	8	.....	.20
.820	.557	.896	.758	NW...	NW...	NW...	4.2	6.0	6.4	5.3	N. 45 W.	8	7	10	.....	.....
.893	.905	.797	.865	NW...	NW...	NW...	3.0	2.0	0.6	1.7	N. 45 W.	7	6	10	.....	.....
.893	.820	.898	.834	NE....	NE....	NE....	6.0	1.0	3.0	3.3	N. 45 E.	0	0	8	.....	.....
.895	.898	.895	.863	NE....	NE....	NE....	1.0	2.0	3.0	2.0	N. 45 E.	10	10	10	.....	.08
.895	.900	.895	.897	NE....	NE....	NE....	1.0	3.0	0.6	1.6	N. 45 E.	10	10	8	.....	.62
.820	.727	.738	.762	SW...	SW...	Calm..	0.6	3.0	0.0	1.2	S. 45 W.	10	8	2	.....	.....
.920	.920	.777	.872	SW...	NE....	NE....	1.0	2.0	2.1	1.0	N. 45 E.	0	3	3	.....	.....
.820	.829	.912	.854	NE....	NE....	NE....	2.0	4.2	2.0	2.7	N. 45 E.	4	6	8	.....	.....
.912	.777	.893	.861	NE....	NE....	NE....	1.0	1.5	1.9	1.6	N. 45 E.	10	10	2	.....	.....
.905	.910	.905	.907	NE....	NE....	NE....	0.6	3.0	1.0	1.6	N. 45 E.	7	10	0	.....	.....
.914	.840	.914	.889	NE....	NE....	Calm..	1.0	2.0	0.0	1.0	N. 45 E.	0	3	10	.....	.04
.907	.847	.912	.889	NE....	NE....	Calm..	1.0	0.8	0.0	0.6	N. 45 E.	10	2	0	.....	.26
.750	.816	.912	.826	NW...	E.....	NE....	2.0	3.2	4.2	2.0	N. 47 E.	3	1	2	.....	.....
.914	.829	.914	.886	NE....	NE....	NE....	1.5	6.0	3.0	3.4	N. 45 E.	5	9	8	.....	.....
.910	.912	.914	.912	NE....	NE....	NE....	6.0	6.0	5.0	5.4	N. 45 E.	10	10	10	.....	.....
.912	.833	.912	.852	NE....	NE....	Calm..	4.0	6.0	0.0	3.3	N. 45 E.	10	9	10	.....	.24
.836	.923	.914	.891	NE....	NE....	Calm..	3.0	3.5	0.0	2.3	N. 45 E.	8	8	10	.....	.....
.638	.914	.910	.821	NE....	NE....	SW...	0.5	3.0	1.5	0.7	N. 45 E.	1	5	0	.....	.....
.914	.452	.918	.761	SW...	NE....	NE....	1.2	0.5	1.0	0.3	N. 45 E.	9	7	10	.....	.....
.847	.864	.918	.876	SW...	NW...	SW...	0.5	3.0	0.5	1.0	N. 55 W.	6	8	9	.....	.35
.920	.861	.907	.896	NE....	NE....	Calm..	6.0	3.0	0.0	3.0	N. 45 E.	10	4	0	.....	.11
.777	.843	.916	.845	NE....	NE....	NE....	2.0	3.0	2.0	2.3	N. 45 E.	5	6	2	.....	.....
.836	.916	.918	.890	NE....	NE....	NE....	3.0	3.0	3.0	3.0	N. 45 E.	8	3	0	.....	.....
.836	.918	.912	.889	NE....	NE....	NE....	4.5	6.0	1.0	4.0	N. 45 E.	10	10	10	.....	.....
.927	.564	.592	.694	NE....	SW...	SW...	0.5	6.0	2.0	2.6	S. 45 W.	10	5	3	.....	.11
.923	.859	.843	.875	NE....	NE....	NW...	8.0	3.0	1.0	3.7	N. 40 E.	0	0	0	.....	.....
.920	.840	.847	.869	N.....	NE....	N.....	1.0	3.0	2.0	2.0	N. 20 E.	10	9	10	.....	.....
.868	.808	.856	.844	.....	.....	.....	....	....	....	1.6	N. 29 E.	6.6	6.1	5.8	.....	2.05
.843	.920	.921	.895	N.....	NE....	NE....	1.0	1.0	3.0	1.3	N. 37 E.	9	10	10	.....	.....
.933	.869	.929	.910	N.....	N.....	SW...	6.0	5.0	0.5	3.7	N. 5 W.	10	10	0	.....	.59
.805	.569	.695	.690	SW...	SW...	W....	3.0	2.5	1.0	2.0	S. 51 W.	3	9	1	.....	.....
.864	.929	.923	.905	NE....	NE....	NE....	1.0	2.0	2.0	1.7	N. 45 E.	2	3	0	.....	.....
.859	.802	.926	.862	NE....	NE....	SW...	1.0	0.5	0.5	0.3	N. 45 E.	7	8	10	.....	.....
.923	.925	.923	.924	NW...	NE....	NE....	3.0	6.0	8.0	4.7	N. 33 E.	10	10	10	.....	.70
.918	.920	.918	.919	NE....	NE....	NE....	13.0	12.0	12.0	12.0	N. 45 E.	10	10	10	.....	1.50
.920	.923	.923	.922	NE....	NE....	NE....	4.0	6.5	2.0	4.0	N. 45 E.	10	10	10	.....	.....
.926	.929	.925	.927	N.....	N.....	N.....	3.0	2.4	1.5	2.3	North..	10	10	10	.....	.....
.937	.551	.882	.790	SW...	SW...	SW...	0.5	9.0	1.0	3.4	S. 45 W.	8	7	3	.....	.49
.783	.304	.772	.620	SW...	SW...	SW...	8.0	9.0	1.0	6.0	S. 45 W.	0	5	8	.....	.....
.825	.769	.927	.840	NE....	NE....	NE....	1.0	1.5	3.0	1.7	N. 45 E.	1	5	3	.....	.....
.937	.932	.930	.933	NE....	NE....	NE....	4.5	10.0	6.0	6.7	N. 45 E.	9	10	10	.....	.84
.882	.537	.790	.736	SW...	SW...	SW...	3.6	4.5	0.5	2.6	S. 45 W.	8	5	3	.....	.31
.723	.747	.822	.764	W.....	NW...	SW...	0.5	6.0	1.0	2.3	N. 58 W.	5	9	9	.....	.....
.934	.925	.925	.928	NE....	NE....	NE....	2.5	6.0	9.0	5.6	N. 45 E.	3	10	10	.....	.....
.929	.882	.934	.915	E.....	NW...	NW...	0.5	3.0	0.5	1.0	N. 39 W.	10	9	2	.....	.84
.672	.558	.653	.628	SW...	SW...	SW...	4.5	4.0	1.5	3.0	S. 45 W.	5	9	0	.....	.....
.836	.937	.925	.899	SW...	NE....	NE....	0.5	6.0	1.5	2.3	N. 45 E.	10	10	10	.....	.....
.923	.923	.923	.923	NE....	NE....	NE....	6.0	6.0	4.0	5.0	N. 45 E.	10	10	10	.....	.83
.925	.929	.861	.905	NE....	NE....	SE....	1.0	0.5	0.5	0.7	N. 71 E.	10	10	10	.....	.....
.945	.648	.935	.843	SW...	NE....	NE....	2.0	2.0	1.0	0.2	N. 45 E.	0	0	0	.....	.21
.929	.934	.929	.931	NE....	NE....	NE....	4.0	3.0	2.0	3.0	N. 45 E.	10	10	10	.....	.....
.926	.929	.929	.928	NE....	NE....	NE....	2.0	4.0	1.0	2.3	N. 45 E.	10	10	10	.....	.70
.941	.802	.930	.891	SW...	SW...	Calm..	2.5	6.0	0	2.6	N. 45 W.	5	10	0	.....	1.12
.934	.935	.935	.935	NE....	N.....	SW...	2.0	1.2	5.5	1.0	S. 67 W.	9	8	10	.....	.....
.822	.690	.822	.778	NW...	NE....	Calm..	4.0	0.5	0	1.3	N. 39 W.	3	4	0	.....	.11
.825	.629	.890	.781	SW...	NE....	Calm..	1.0	1.5	0	0.2	N. 45 E.	0	1	8	.....	.....
.884	.548	.824	.752	N.....	SW...	SW...	1.5	6.0	1.0	2.0	S. 54 W.	3	1	10	.....	.....
.743	.689	.831	.754	N.....	N.....	SW...	4.0	3.6	1.0	2.3	N. 7 W.	5	5	10	.....	.....
.875	.786	.875	.845	.....	.....	.....	....	....	....	1.2	N. 25 E.	6.5	7.6	6.6	.....	8.24

Reductions of the monthly meteorological register of the survey of the

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity. U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
July 1	29.274	29.188	29.163	29.208	62	72	70	63	83	72	72.7	75	71	.542	.636	.706	.628
2	29.188	29.138	29.156	29.161	64	78	69	65	85	74	74.7	77	76	.583	.863	.641	.696
3	29.158	29.015	29.167	29.113	56	60	54	57	61	55	57.7	56	53	.436	.505	.404	.448
4	29.230	29.180	29.177	29.196	55	54	53	56	55	55	55.3	50	48	.429	.404	.376	.403
5	29.148	29.108	29.148	29.135	55	77	60	56	69	62	62.3	63	61	.420	....	.491	.456
6	29.164	29.085	29.294	29.181	63	60	55	66	62	56	61.3	56	54	.536	.491	.420	.482
7	29.332	29.359	29.406	29.366	62	62	54	63	70	55	62.7	57	56	.542	.449	.404	.498
8	29.442	29.446	29.446	29.445	55	63	55	59	71	56	62.0	57	55	.380	.469	.420	.423
9	29.417	29.226	29.098	29.247	61	67	69	64	78	70	70.7	72	68	.497	.514	.695	.569
10	28.898	28.860	28.977	28.912	69	80	63	70	83	66	73.0	70	65	.695	.982	.536	.738
11	29.208	29.363	29.431	29.334	62	69	58	65	70	62	65.7	63	60	.516	.695	.429	.547
12	29.514	29.436	29.409	29.453	55	58	56	56	59	57	57.3	58	55	.420	.469	.436	.442
13	29.407	29.399	29.266	29.357	56	60	63	57	61	64	60.7	67	63	.436	.505	.562	.501
14	29.204	28.948	29.149	29.100	64	64	57	65	65	59	63.0	62	57	.583	.583	.439	.535
15	29.337	29.401	29.406	29.381	57	63	55	59	67	56	60.7	59	55	.439	.522	.420	.460
16	29.467	29.364	29.329	29.387	60	61	57	63	62	59	61.3	61	56	.478	.523	.439	.480
17	29.314	29.253	29.246	29.271	61	69	56	62	75	57	64.7	60	56	.523	.628	.436	.529
18	29.209	20 196	29.238	29.214	61	66	64	62	67	65	64.7	57	55	.523	.636	.583	.577
19	29.266	29.276	29.353	29.298	60	67	63	61	79	69	69.7	64	63	.505	.501	.495	.500
20	29.472	29.424	29.376	29.424	58	57	58	59	58	59	58.7	59	57	.469	.452	.469	.463
21	29.342	29.223	29.217	29.261	63	65	63	65	66	64	65.0	55	53	.549	.604	.562	.572
22	29.236	29.172	29.190	29.199	74	80	73	77	92	75	81.3	76	74	.799	.860	.789	.816
23	29.168	29.210	29.222	29.200	70	77	74	71	81	75	75.7	75	73	.720	.873	.826	.806
24	29.260	29.260	29.168	29.229	70	63	63	71	69	64	68.0	63	61	.720	.495	.562	.592
25	29.261	29.208	29.221	29.230	63	62	61	66	63	63	64.0	63	60	.536	.542	.510	.529
26	29.219	29.093	28.990	29.101	61	73	68	63	70	69	67.3	69	66	.510	....	.671	.591
27	28.940	28.902	29.010	28.951	74	79	63	75	82	67	74.7	68	66	.826	.949	.522	.766
28	29.025	29.373	29.398	29.265	64	62	56	70	66	59	65.0	59	57	.516	.502	.409	.476
29	29.522	29.491	29.433	29.482	64	68	62	70	79	65	71.3	66	64	.516	.537	.516	.523
30	29.381	29.174	29.159	29.238	60	62	59	61	63	60	61.3	58	56	.505	.542	.487	.511
31	29.101	29.028	29.080	29.070	63	67	64	64	68	65	65.7	65	63	.562	.648	.583	.598
Means.	29.261	29.220	29.236	29.239	62.0	66.6	61.1	63.6	69.3	63.0	65.3	77	48	.507	.599	.534	.553
August 1	29.156	29.178	29.228	29.187	60	70	65	61	79	66	68.7	67	65	.505	.612	.604	.574
2	29.344	29.298	29.294	29.312	63	62	59	64	63	40	55.7	63	57	.562	.542	....	.552
3	29.252	29.241	29.241	29.245	68	70	74	69	71	75	71.7	77	73	.671	.720	.896	.739
4	29.406	29.388	29.393	29.396	67	74	68	72	81	69	74.0	71	69	.595	.745	.671	.670
5	29.373	29.298	29.311	29.327	63	69	67	64	71	68	67.7	67	65	.562	.682	.648	.630
6	29.321	29.258	29.248	29.276	68	78	73	69	84	75	76.0	70	68	.671	.877	.784	.777
7	29.333	29.301	29.354	29.329	64	62	68	65	63	69	65.7	67	66	.583	.542	.671	.599
8	29.178	29.067	29.229	29.155	63	76	66	64	90	67	73.7	67	65	.562	.708	.636	.635
9	29.431	29.428	29.473	29.444	59	65	61	63	79	63	68.0	66	62	.447	.431	.523	.467
10	29.589	29.511	29.458	29.519	57	71	67	59	84	69	70.7	75	69	.420	.583	.635	.552
11	29.396	29.248	29.100	29.248	66	75	68	70	84	74	79.3	76	72	.595	.746	.604	.645
12	29.077	29.145	29.191	29.138	67	78	70	68	79	74	73.7	69	64	.649	.945	.679	.757
13	29.254	29.176	29.326	29.252	59	68	66	61	79	70	70.0	66	66	.473	.537	.586	.532
14	29.371	29.391	29.411	29.391	60	67	66	62	75	67	68.0	67	65	.491	.554	.626	.557
15	29.491	29.423	29.364	29.426	61	65	59	62	66	60	62.7	62	61	.523	.604	.467	.531
16	29.211	29.095	29.176	29.161	63	66	63	64	67	64	65.0	61	60	.562	.636	.568	.589
17	29.015	29.037	29.125	29.059	69	69	66	72	72	70	81.3	63	62	.668	.668	.586	.641
18	29.363	29.261	29.284	29.303	65	65	64	68	69	66	67.7	62	61	.577	.564	.569	.570
19	29.381	29.346	29.358	29.362	60	65	64	61	66	65	64.0	65	62	.505	.604	.583	.564
20	29.401	29.291	29.298	29.330	63	67	65	64	68	66	66.0	66	64	.562	.648	.604	.605
21	29.301	29.228	29.203	29.244	62	68	65	63	70	66	66 3	67	63	.542	.658	.604	.601
22	29.063	29.072	29.065	29.067	63	66	64	64	67	65	65.3	66	64	.562	.636	.583	.594
23	29.193	29.196	29.286	29.225	58	67	63	69	78	65	70.7	70	64	.336	.514	.549	.466
24	29.412	29.364	29.321	29.366	56	64	59	59	69	60	62.7	61	59	.409	.529	.487	.475
25	29.304	29.370	29.338	29.337	65	60	67	68	77	68	71.0	70	67	.577	.485	.649	.570
26	29.301	29.163	29.175	29.213	63	74	66	64	86	69	73.0	69	68	.562	.677	.598	.612
27	29.038	29.075	29.164	29.092	62	65	57	63	78	60	67.0	60	59	.542	.443	.498	.470
28	29.270	29.289	29.347	29.302	52	60	53	57	68	54	59.7	55	52	.392	.411	.389	.374
29	29.460	29.462	29.467	29.463	55	59	48	56	64	49	56.3	50	48	.420	.433	.392	.389
30	29.421	29.234	29.164	29.273	47	61	59	48	74	65	62.3	66	63	.310	.363	.420	.364
31	29.189	29.380	29.415	29.328	57	52	50	58	55	51	54.7	53	50	.452	.349	.348	.383
Means.	29.300	29.265	29.284	29.283	61.4	67.0	63.5	63.6	73.4	64.8	67.4	77	48	.523	.592	.556	.583

northern and northwestern lakes at Superior City, Wisconsin.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation=1,000.				Direction. From whence.			Velocity, in miles per hour.			Resultant velocity, in miles per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 a. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.942	.564	.900	.802	SW..	SW..	SW..	2.0	3.0	0.5	1.6	S. 45 W.	8	7	7	.....	.....
.944	.718	.764	.809	Calm..	SW...	Calm..	0	2.0	0	0.7	S. 45 W.	10	5	0	.....	.....
.936	.941	.934	.937	N.....	NE...	NE...	2.0	5.0	2.0	2.7	N. 38 E.	10	10	10	.....	1.71
.935	.934	.869	.913	NE...	NE...	NE...	0.5	3.0	1.0	1.6	N. 45 E.	10	10	10	.....	.....
.935	.....	.884	.910	W.....	NW..	SW..	0.5	4.0	1.0	1.7	N. 65 W.	10	0	2	.....	.....
.838	.884	.935	.886	SW..	NE...	SW..	0.5	3.0	1.0	0.6	N. 45 E.	7	10	1	.....	.....
.942	.613	.934	.830	SW..	SW..	Calm..	6.0	9.0	0	5.0	S. 45 W.	3	7	0	.....	.03
.761	.618	.935	.771	SW..	W....	SW..	0.5	4.0	1.0	2.0	S. 80 W.	4	7	0	.....	.....
.833	.537	.948	.773	NE...	SW..	SW..	3.0	9.0	5.0	3.6	S. 45 W.	2	9	10	.....	.....
.948	.871	.838	.886	SW..	SW..	SW..	3.0	2.0	4.0	3.0	S. 45 W.	8	8	0	.....	.52
.836	.948	.772	.852	NW...	NW..	NE...	2.0	0.5	2.0	1.0	N. 10 W.	8	8	9	.....	.....
.935	.939	.936	.970	NE...	NE...	NE...	5.0	4.0	2.0	3.6	N. 45 E.	3	4	1	.....	.....
.935	.941	.943	.940	NE...	NE...	SW..	3.0	6.0	0.5	2.2	N. 45 E.	2	7	5	.....	.....
.944	.944	.878	.922	N.....	SW..	SW..	3.0	0.5	2.0	0.7	N. 51 W.	10	10	1	.....	.....
.878	.790	.935	.868	SW..	NW..	Calm..	3.0	4.0	0	1.7	N. 81 W.	0	0	0	.....	.58
.831	.942	.878	.884	SW..	NE...	NE...	0.5	3.0	3.0	1.6	N. 45 E.	4	0	3	.....	.....
.942	.724	.936	.867	N.....	SW..	NE...	4.0	4.5	2.0	1.0	S. 35 W.	8	10	10	.....	.....
.942	.946	.944	.944	SW..	NE...	SW..	2.0	6.0	1.0	1.0	N. 45 E.	10	9	10	.....	1.90
.941	.506	.700	.716	SW..	SW..	SW..	4.0	1.0	1.0	2.0	S. 45 W.	0	0	0	.....	.71
.939	.937	.939	.938	NE...	NE...	NE...	1.0	2.0	1.0	1.3	N. 45 E.	0	10	0	.....	.....
.890	.545	.943	.793	NE...	NE...	NE...	0.5	1.0	0.5	0.7	N. 45 E.	0	0	0	.....	.....
.862	.573	.904	.721	SW..	SW..	SW..	6.0	6.0	0.5	4.0	S. 45 W.	4	6	7	.....	.....
.949	.826	.952	.909	Calm..	SW..	SW..	0	1.0	0.5	0.6	S. 45 W.	8	9	1	.....	.....
.949	.700	.943	.864	N.....	NE...	NE...	1.0	6.0	4.0	3.7	N. 43 E.	10	9	9	.....	.....
.838	.942	.886	.889	NE...	NE...	NE...	2.0	1.0	4.0	2.3	N. 45 E.	0	2	1	.....	.....
.886	.....	.947	.917	SW..	NE...	SW..	0.5	2.0	0.5	0.3	N. 45 E.	1	2	0	.....	.....
.952	.870	.790	.871	SW..	SW..	SW..	0.3	0.5	3.0	1.3	S. 45 W.	2	10	0	.....	.....
.704	.786	.819	.770	NW..	NW..	SW..	6.0	3.0	0.5	3.0	N. 48 W.	4	4	0	.....	.....
.704	.542	.836	.727	NW.	NW..	SW..	2.0	2.0	3.0	1.7	N. 81 W.	0	5	5	.....	.....
.941	.942	.940	.941	Calm..	NE...	NE...	0	3.0	2.0	1.7	N. 45 E.	8	10	10	.....	.....
.943	.947	.944	.945	SW..	SW..	NW..	3.0	2.0	1.0	1.7	S. 57 W.	9	8	7	.....	.70
.895	.792	.894	.863	.....	.....	.....	....	....	....	0.4	N. 59 W.	5.3	6.3	3.8	.....	6.15
.941	.618	.945	.835	NW..	NW..	SW..	3.0	3.0	2.0	2.0	N. 64 W.	9	5	0	.....	.20
.943	.942	.....	.943	Calm..	NE...	NE...	0	4.0	6.0	3.3	N. 45 E.	0	3	1	.....	.....
.947	.949	.952	.947	NE...	SW..	SW..	2.0	4.0	2.0	1.3	S. 45 W.	10	9	3	.....	.....
.758	.704	.947	.803	SW..	NE...	Calm..	6.5	1.0	0	1.7	S. 45 W.	0	0	0	.....	.04
.943	.899	.947	.930	NE...	NE...	SW..	3.0	1.0	0.5	1.3	N. 45 E.	10	3	5	.....	.....
.947	.753	.904	.868	N.....	SW..	Calm..	4.0	0.5	0	1.3	N. 10 W.	7	5	0	.....	.02
.944	.942	.947	.944	NE..	NE...	Calm..	1.0	2.0	0	1.0	N. 45 E.	10	10	10	.....	.....
.943	.503	.946	.797	NE...	SW..	NW..	1.0	1.0	2.0	0.7	N. 45 W.	10	3	10	.....	.....
.776	.434	.942	.717	Calm..	NW..	SW..	0	7.0	0.5	2.3	N. 48 W.	0	2	0	.....	.99
.878	.501	.896	.758	SW..	SW..	SW..	3.0	2.0	0.5	1.7	S. 45 W.	0	6	5	.....	.....
.799	.640	.720	.720	SW..	SW..	SW..	1.0	6.0	6.0	4.0	S. 45 W.	10	8	10	.....	.08
.947	.954	.810	.904	SW..	SW..	NW..	4.2	0.5	4.0	2.0	S. 86 W.	10	5	0	.....	.....
.882	.542	.799	.741	SW..	SW..	SW..	1.0	6.0	3.0	3.2	S. 45 W.	0	0	0	.....	.....
.884	.639	.946	.823	Calm..	E....	N.....	0	2.0	2.0	1.0	N. 45 E.	0	2	1	.....	.....
.942	.945	.940	.942	NE...	NE...	NE...	1.0	4.5	6.0	4.0	N. 45 E.	9	1	9	.....	.....
.943	.946	.943	.944	NE...	NE...	SW..	4.0	2.0	1.0	1.7	N. 45 E.	10	10	0	.....	.....
.852	.852	.799	.834	NE...	SW..	SW..	2.0	2.0	3.0	1.0	S. 45 W.	0	8	5	.....	.....
.843	.796	.891	.843	NE...	NE...	NE...	1.0	6.0	2.0	3.0	N. 45 E.	5	2	6	.....	.....
.941	.945	.944	.943	NE...	NE...	NE...	2.0	2.0	2.0	2.0	N. 45 E.	10	10	0	.....	.....
.943	.947	.945	.945	Calm..	NE...	NE..	0	2.0	1.5	1.3	N. 45 E.	10	4	0	.....	.....
.942	.898	.945	.928	Calm..	NE...	NE...	0	3.0	4.0	2.3	N. 45 E.	10	9	10	.....	.....
.943	.946	.944	.944	NE...	NE...	SW..	2.0	0.5	2.0	0.2	N. 45 E.	10	10	0	.....	.....
.475	.537	.890	.634	SW..	NW..	SW..	1.0	4.8	0.5	1.7	N. 62 W.	0	0	0	.....	.02
.819	.747	.940	.835	NW..	NE...	SW..	0.5	2.0	0.5	0.7	N. 25 E.	0	0	0	.....	.....
.843	.642	.947	.811	SW..	SW..	SW..	2.0	6.0	1.0	3.0	N. 45 W.	8	0	0	.....	.....
.943	.545	.846	.778	SW..	SW..	SW..	1.0	3.6	0.5	1.7	S. 45 W.	1	0	0	.....	.....
.942	.463	.822	.742	Calm..	NW..	W....	0	7.5	2.0	3.0	N. 45 W.	8	1	0	.....	.....
.692	.601	.933	.742	NW..	SW..	SW..	7.2	9.0	2.0	4.7	S. 81 W.	0	6	7	.....	.....
.935	.727	.926	.863	SW..	Calm..	SW..	0.5	0	2.5	1.0	S. 45 W.	4	6	0	.....	.....
.925	.433	.680	.679	SW..	SW..	SW..	3.0	10.0	3.0	5.3	S. 45 W.	9	1	2	.....	.....
.937	.805	.929	.890	NE...	NE...	NE...	10.5	4.0	0.5	5.0	N. 45 E.	1.0	5	1	.....	.06
.884	.735	.870	.840	.....	.....	.....	....	....	....	0.5	N. 63 W.	5.8	4.3	2.7	.....	1.41

SACKETT'S HARBOR NEW YORK

Maximum, minimum, and mean temperature for each month from the year 1859 to 1867, inclusive.

Year.	July.			August.			September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1859	85	49	69.1	86	51	69.9	75	41	59.2	75	23	45.9	61	23	39.8	57	—21	20.4
1860	77	57	66.4	87	44	68.1	79	28	59.0	71	29	50.1	73	16	40.3	43	—15	22.5
1861	85	50	67.7	85	45	67.6	79	43	61.0	70	26	50.9	53	15	37.6	61	— 8	30.5
1862	82	50	69.6	88	43	71.1	84	40	65.0	82	27	52.4	64	10	37.9	49	—14	26.3
1863	85	52	72.4	93	45	71.6	83	33	60.7	76	23	51.0	65	14	43.1	55	— 5	26.3
1864	91	54	73.3	92	52	73.0	80	37	61.6	70	34	49.8	68	14	40.3	53	—12	28.7
1865	84	48	69.2	89	47	72.8	88	39	68.9	66	24	47.7	54	17	41.6	58	— 3	31.4
1866	88	49	74.3	81	46	66.3	85	37	60.7	77	26	53.2	.....	.....	.....	54	—30	27.3
1867	88	48	69.3	88	47	71.7	85	34	60.2	77	24	50.9	63	8	37.3	49	—19	17.6

SACKETT'S HARBOR, NEW YORK.

Maximum, minimum, and mean temperature for seasons and years from 1859 to 1867, inclusive.

Year.	Spring.			Summer.			Autumn.			Winter.			Year.			Range.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1859	.....	.....	.....	.....	.....	.....	75	23	48.3	.....	.....	.....	.....	.....	.....	.....
1860	76	12	55.6	87	44	66.4	79	16	49.8	57	—21	22.5	87	—21	46.3	108
1861	70	—13	39.9	85	44	65.7	79	15	49.8	50	—46	22.1	85	—46	45.0	131
1862	81	1	41.2	88	36	67.7	84	10	51.8	61	—21	23.8	88	—21	45.8	109
1863	80	—34	41.0	93	45	69.3	83	14	51.6	56	—30	26.3	93	—34	47.1	127
1864	76	0	44.8	92	42	70.7	80	14	50.6	55	—24	26.6	92	—24	48.4	116
1865	80	— 9	47.2	89	47	70.6	88	17	52.7	53	—40	22.1	89	—40	48.4	129
1866	74	2	43.0	88	46	68.7	85	24.7	.....	58	—26	24.7	88	—30	47.2	118
1867	70	0	40.7	88	45	69 6	85	8	49.5	54	—32	24.0	88	—32	45.1	120

SACKETT'S HARBOR, NEW YORK.

Year.	Amount of rain and melted snow for months, seasons, and years in United States inches and decimals.																
	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
1859							1.62	3.28	2.64	0.98	4.16	5.18			7.78		
1860	1.95	1.52	1.39	1.26	1.88	2.11	4.79	2.90	3.70	3.64	6.52	2.96	4.53	9.80	13.86	8.65	34.62
1861	2.66	5.82	2.68	2.70	4.48	2.10	6.32	4.04	5.80	4.62	3.38	1.30	9.86	12.46	13.80	11.44	45.90
1862	1.13	1.46	4.20	2.14	2.42	1.68	3.60	1.64	2.96	3.72	2.54	2.27	8.76	6.92	6.22	3.89	29.76
1863	2.26	3.08	2.07	3.34	2.02	2.34	2.56	3.44	2.40	5.44	4.70	4.50	7.43	8.34	12.54	7.61	38.15
1864	2.56	1.78	2.72	4.80	6.76	1.14	1.14	3.02	2.94	5.94	5.36	3.38	14.28	5.30	14.24	8.84	41.34
1865	1.58	1.22	3.94	3.30	2.59	4.08	2.28	0.56	1.73	4.78	2.26	2.30	9.83	6.92	8.77	6.18	30.62
1866	1.26	2.70	2.82	2.88	3.22	3.84	1.50	5.88	5.34	2.90	4.12	2.46	8.92	11.22	12.36	6.26	38.92
1867	0.86	3.00	1.56	3.30	5.80	1.02	2.10	1.34	2.84	2.08	1.78	1.52	10.66	4.46	6.70	6.32	27.20

Reductions of the monthly meteorological register of the survey of

Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.				
				Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity in U.S. inches and decimals.				
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
				o	o	o	o	o	o	o	o	o				
28.797	28.791	28.944	28.844	45	52	40	48	54	43	48.3	64	37	.260	.362	.208	.277
29.152	29.165	29.137	29.151	33	36	34	35	40	35	36.7	42	32	.162	.160	.183	.168
29.023	28.992	29.037	29.017	34	35	31	35	37	32	34.7	40	30	.183	.178	.162	.174
29.163	29.296	29.312	29.257	23	35	29	24	39	30	31.0	42	20	.112	.152	.149	.138
29.431	29.526	29.542	29.503	23	38	27	25	43	28	32.0	45	20	.100	.164	.136	.133
29.465	29.304	29.195	29.328	27	39	37	28	40	38	35.3	40	18	.136	.225	.207	.189
28.815	28.676	28.653	28.715	38	45	44	40	47	45	44.0	48	36	.203	.273	.275	.250
28.393	28.512	28.503	28.469	41	46	40	43	54	43	46.7	54	40	.231	.206	.208	.215
28.456	28.668	28.904	28.676	34	34	31	35	35	32	34.0	42	30	.183	.183	.162	.176
29.043	29.105	29.230	29.126	30	30	29	31	31	30	30.7	35	28	.155	.155	.149	.153
29.415	29.507	29.620	29.514	26	33	22	27	35	23	28.3	36	20	.129	.162	.107	.132
29.623	29.416	29.386	29.475	24	45	34	25	48	35	36.0	48	17	.117	.260	.183	.187
29.315	29.094	29.189	29.199	23	41	40	25	44	42	37.0	45	20	.100	.218	.221	.180
29.430	29.441	29.486	29.452	29	41	27	30	48	28	35.3	50	26	.149	.166	.136	.150
29.338	29.085	29.334	29.252	23	42	35	24	51	37	37.3	54	20	.112	.149	.178	.146
29.580	29.524	29.376	29.493	26	34	35	27	35	36	32.7	40	25	.129	.183	.191	.168
29.450	29.469	29.487	29.469	31	36	34	33	38	35	35.3	40	30	.151	.186	.183	.173
29.485	29.464	29.502	29.484	29	31	27	30	32	28	30.0	36	25	.149	.162	.136	.149
29.448	29.236	29.189	29.298	26	35	24	27	37	25	29.7	40	25	.129	.178	.117	.141
29.213	29.289	29.279	29.260	21	40	35	22	41	36	33.0	42	20	.101	.235	.191	.176
29.140	28.989	29.034	29.054	24	44	42	25	47	43	38.3	50	22	.117	.249	.254	.207
29.065	29.069	29.109	29.081	31	43	39	32	45	40	39.0	46	30	.162	.251	.225	.213
29.020	29.064	29.032	29.039	36	40	40	37	41	41	39.7	42	35	.199	.235	.235	.223
29.196	29.137	29.425	29.253	34	33	27	35	34	28	32.3	42	25	.183	.175	.136	.165
29.433	29.405	29.370	29.403	24	29	19	25	30	20	25.0	34	18	.117	.149	.092	.119
29.398	29.392	29.376	29.389	21	31	26	22	32	27	27.0	35	18	.104	.162	.129	.132
29.308	29.314	29.368	29.330	24	28	21	27	30	22	26.3	33	20	.095	.130	.104	.110
29.377	29.396	29.439	29.404	18	17	7	20	18	8	15.3	25	8	.076	.083	.048	.069
29.458	29.398	29.456	29.437	- 4	5	- 7	-3	6	- 6	- 1.0	12	- 8	.026	.043	.020	.030
29.470	29.310	29.231	29.337	-16	12	6	-15	13	7	- 5.0	14	-19	.009	.063	.046	.039
29.231	29.202	29.238	29.224	25.9	35.0	29.2	27.3	37.5	30.4	31.7	64	-19	.136	.183	.159	.159
29.127	29.124	29.094	29.115	14	23	24	15	25	25	21.7	26	5	.071	.100	.117	.096
29.297	29.292	29.350	29.313	19	28	19	20	30	20	23.3	32	19	.092	.170	.092	.105
29.553	29.484	29.411	29.483	0	12	6	1	13	7	10.0	22	- 1	.032	.063	.046	.047
29.237	29.136	29.184	29.186	12	21	5	13	22	6	13.7	23	5	.063	.101	.043	.069
29.185	29.004	28.786	28.992	- 7	14	18	- 6	15	19	09.3	19	- 8	.020	.071	.087	.059
28.447	29.077	29.389	28.971	21	14	- 6	22	15	- 5	10.7	24	- 5	.101	.071	.021	.064
29.520	29.525	29.633	29.559	-17	7	- 3	-16	8	- 2	-03.3	10	-18	.008	.048	.026	.027
29.654	29.608	29.596	29.619	- 7	14	0	- 6	15	1	03.3	16	-10	.020	.071	.032	.041
29.378	29.221	29.323	29.307	11	25	21	12	20	22	20.0	26	- 2	.061	.123	.101	.095
29.332	29.263	29.238	29.278	14	18	19	15	21	20	18.7	24	12	.071	.065	.092	.076
29.349	29.401	29.462	29.404	19	19	19	20	20	20	20.0	24	15	.092	.092	.092	.092
29.509	29.431	29.403	29.448	13	20	9	14	21	10	15.0	21	9	.067	.096	.054	.072
29.310	29.271	29.293	29.291	13	24	19	15	25	20	20.0	26	0	.056	.117	.092	.088
29.321	29.300	29.320	29.314	19	23	19	20	24	20	21.3	24	16	.092	.112	.092	.099
29.226	29.150	29.130	29.169	21	26	23	22	27	24	24.3	27	20	.101	.129	.112	.114
29.051	28.960	28.940	28.984	23	25	26	24	26	27	25.7	28	20	.112	.123	.129	.121
29.263	29.413	29.549	29.408	3	9	- 6	4	10	- 5	03.0	26	- 6	.038	.054	.021	.038
29.748	29.838	29.685	29.757	-21	7	- 4	-20	8	- 3	-05.0	10	-23	.004	.048	.025	.026
29.546	29.337	29.181	29.355	4	14	15	5	15	16	12.0	18	- 5	.041	.071	.074	.062
29.400	29.521	29.561	29.494	3	17	0	4	18	- 1	07.0	20	- 2	.038	.083	.032	.051
29.411	29.124	28.861	29.132	4	22	29	5	23	30	19.3	30	- 7	.041	.107	.149	.099
29.003	29.143	29.467	29.204	21	16	0	22	17	- 1	12.7	28	- 1	.101	.078	.032	.070
29.577	29.316	29.097	29.330	-16	1	9	-15	2	10	-01.0	17	-18	.009	.034	.054	.032
29.142	29.181	29.141	29.155	12	17	22	13	18	23	18.0	25	10	.063	.083	.107	.084
28.659	.....	29.071	28.865	29	....	5	30	....	6	18.0	33	5	.149	....	.043	.096
29.225	29.030	28.875	29.043	- 6	9	17	- 5	10	18	07.7	23	-10	.021	.054	.083	.053
28.949	29.161	29.367	29.159	7	11	5	8	12	6	08.7	22	5	.048	.061	.043	.051
29.448	29.195	29.495	29.379	- 9	7	1	- 8	8	2	00.7	10	-10	.017	.048	.034	.033
29.769	29.763	29.830	29.787	-11	13	1	-10	14	2	02.0	16	10	.014	.067	.034	.038
29.894	29.747	29.631	29.757	-18	18	4	-17	19	5	02.3	21	-18	.007	.087	.041	.045
29.313	29.123	29.006	29.147	- 8	28	16	- 7	30	18	13.7	32	-10	.018	.130	.067	.072
29.317	29.304	29.302	29.304	05.2	16.7	10.7	06.3	17.9	11.6	12.0	33	-23	.054	.084	.067	.068

the northern and northwestern lakes at Superior City, Wisconsin.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
.777	.867	.750	.798	NW...	S.....	SE....	3.0	1.0	0.6	0.3	N. 25 E.	8	0	0	.....	.....
.797	.645	.898	.780	NW...	NW...	Calm..	1.6	2.4	.0	1.3	N. 45 W	3	10	10	.....	.....
.898	.807	.896	.867	NE ...	N.....	SW ...	4.2	1.2	6.0	1.3	S. 83 W	10	10	6	.....	.10
.868	.636	.890	.798	SW ...	SW ...	SW ...	2.4	9.6	4.2	5.3	S. 45 W	0	3	4	.....	.....
.746	.587	.883	.739	SW ...	NW ...	NW ...	15.4	8.4	1.0	6.0	S. 76 W	0	6	0	.....	.....
.883	.910	.905	.899	NW ...	NE ...	NE ...	2.4	20.0	4.2	8.0	N. 40 E	0	7	8	.....	.....
.820	.847	.920	.862	NE ...	NE ...	NE ...	1.0	1.8	1.0	1.3	N. 45 E.	5	8	9	.....	.....
.833	.493	.750	.692	SW ...	SW ...	SW ...	0.6	10.0	10.8	7.3	S. 45 W	10	4	3	.....	.....
.898	.898	.896	.897	NW ...	NW ...	NW ...	8.4	12.0	3.6	7.6	N. 45 W	10	10	0	.....	.....
.893	.893	.890	.892	NW ...	NW ...	NW ...	4.2	3.6	1.0	3.0	N. 45 W	6	10	10	.....	.....
.880	.797	.864	.847	NW ...	NW ...	NW ...	1.0	4.0	1.0	2.0	N. 45 W	10	2	0	.....	.....
.872	.777	.898	.849	NW ...	NW ...	Calm..	0.6	5.0	.0	1.7	N. 45 W	4	0	0	.....	.....
.746	.756	.829	.777	NW ...	Calm .	N	1.0	.0	3.6	1.7	N. 9 W	0	0	4	.....	.....
.890	.494	.883	.756	NW ...	NW ...	Calm..	1.0	2.0	.0	1.0	N. 45 W	0	0	0	.....	.....
.868	.399	.807	.691	Calm..	NW ...	NW ...	.0	6.0	8.4	5.0	N. 45 W	10	0	5	.....	.....
.880	.898	.900	.893	NW ...	NW ...	NW ...	2.0	3.0	4.2	3.0	N. 45 W	0	10	10	.....	.....
.800	.811	.898	.836	Calm..	Calm..	NE ...	.0	.0	2.0	0.7	N. 45 E.	5	3	8	.....	.....
.890	.896	.883	.890	Calm..	NE ...	NE ...	.0	3.0	2.0	1.7	N. 45 E.	10	10	10	.....	.....
.880	.807	.872	.853	E	SE....	Calm..	0.6	1.2	.0	0.7	S. 77 E.	10	4	0	.....	.12
.860	.912	.900	.891	SW ...	NE ...	NE ...	1.0	1.2	3.0	1.0	N. 45 E.	0	0	3	.....	.....
.872	.772	.916	.853	Calm..	NW ...	Calm..	.0	3.6	.0	1.3	N. 45 W	4	3	10	.....	.....
.896	.840	.910	.882	Calm..	Calm..	NE ...	.0	.0	2.0	0.7	N. 45 E.	5	0	10	.....	.....
.903	.912	.912	.909	NE ...	NE ...	NE ...	1.0	2.4	1.0	1.6	N. 45 E.	10	10	10	.....	.....
.898	.895	.883	.892	N	Calm..	NW ...	1.0	.0	2.0	1.0	N. 28 W	10	10	8	.....	.....
.872	.890	.850	.871	N	Calm..	Calm..	4.2	.0	.0	1.4	North ..	10	10	6	.....	.....
.860	.896	.880	.879	Calm..	N	Calm..	.0	2.0	.0	0.7	North ..	10	0	10	.....	.....
.644	.782	.860	.762	NW ...	NW ...	N	2.0	2.4	3.6	2.3	N. 26 W	10	8	10	.....	.....
.702	.840	.777	.773	N	N	N	5.4	8.4	3.0	5.6	North ..	10	10	10	.....	.....
.671	.760	.611	.681	NW ...	NW ...	NW ...	2.4	6.4	2.0	3.7	N. 45 W	0	0	0	.....	.....
.423	.810	.769	.667	NW ...	NW ...	SW ...	1.0	3.6	3.0	2.0	N. 79 W	0	0	10	.....	.....
.824	.784	.859	.822	.....	.....	.....	....	....	....	1.5	N. 41 W	5.7	4.9	5.8	.....	.22
.823	.746	.872	.814	SW ...	SW ...	SW ...	0.6	1.0	4.2	2.0	S. 45 W	8	10	10	.....	.....
.850	.782	.850	.827	S	SW ...	SW ...	2.4	5.0	0.6	2.3	S. 29 W	10	8	9	.....	.....
.707	.810	.769	.762	SW ...	SW ...	Calm..	1.0	0.6	.0	0.7	S. 45 W	0	7	10	.....	.....
.810	.860	.760	.810	SW ...	NE ...	Calm..	1.0	1.2	.0	0.2	N. 45 E.	8	6	0	.....	.....
.611	.823	.845	.760	SW ...	SW ...	SW ...	1.9	0.6	2.4	1.2	S. 45 W	0	10	10	.....	.....
.860	.823	.627	.770	W	W....	W....	3.6	18.0	3.6	8.4	West...	10	6	4	.....	.....
.395	.777	.671	.614	SW ...	SW ...	SW ...	1.2	8.4	2.4	4.0	S. 45 W	0	0	0	.....	.25
.611	.823	.707	.714	SW ...	SW ...	Calm..	2.4	1.0	.0	1.0	S. 45 W	0	0	3	.....	.....
.804	.876	.860	.847	Calm..	W....	NW ..	.0	3.0	2.4	1.0	N. 55 W	10	10	10	.....	.....
.823	.570	.850	.748	S	NE ...	Calm..	1.9	1.2	.0	0.7	S. 23 E.	10	8	10	.....	.....
.850	.850	.850	.850	NE ...	NE ...	NE ...	5.4	30.0	15.4	16.6	N. 45 E.	10	10	10	.....	.....
.816	.855	.791	.821	NE ...	Calm.	Calm..	2.4	.0	.0	0.7	N. 45 E.	8	0	4	.....	.02
.648	.872	.850	.790	S	SW ...	Calm..	0.9	1.2	.0	0.7	S. 23 W	6	8	10	.....	.....
.850	.868	.850	.856	SW ...	Calm..	NW ...	1.0	.0	2.0	1.0	N. 73 W	10	10	10	.....	.....
.860	.880	.868	.869	Calm..	SW ...	Calm..	.0	1.0	.0	0.3	S. 45 W	10	8	10	.....	.....
.868	.876	.880	.875	NE ...	NE ...	Calm..	4.2	12.0	.0	5.3	N. 45 E.	10	10	10	.....	.....
.740	.791	.627	.719	N	N	NW ...	12.0	8.4	2.0	1.3	N. 20 W	8	10	6	.....	.38
.269	.777	.658	.568	SW ...	Calm..	Calm..	1.0	.0	.0	3.3	S. 45 W	0	0	6	.....	.....
.750	.823	.829	.801	Calm..	Calm..	Calm..	.0	.0	.0	0.0	Calm..	8	10	10	.....	.....
.740	.840	.710	.763	SW ...	SW ...	Calm..	3.0	1.2	.0	1.3	S. 45 W	0	0	0	.....	.16
.750	.864	.890	.835	W	N	W....	0.6	8.4	1.2	3.0	N. 21 W	10	10	10	.....	.....
.860	.834	.710	.801	SW ...	SW ...	SW ...	2.6	5.4	4.2	4.0	S. 45 W	10	10	8	.....	.24
.423	.718	.791	.644	W	NE ...	Calm..	1.2	2.0	.0	0.3	N. 11 E.	3	10	10	.....	.....
.810	.840	.864	.838	NE ...	NE ...	NE ...	1.0	4.2	9.6	5.0	N. 45 E.	0	10	10	.....	.....
.890	....	.760	.825	E	.....	SW ...	2.0	....	4.2	1.0	S. 17 W	10	....	....	.....	.....
.627	.791	.840	.753	SW ...	NE ...	NE ...	1.0	12.0	200	4.3	N. 45 E.	8	10	10	.....	.....
.777	.804	.760	.780	W	W....	Calm..	2.0	4.2	.0	2.1	West...	10	0	10	.....	.36
.577	.777	.718	.691	SW ...	W....	W....	1.2	5.4	1.0	2.3	S. 84 W	0	8	3	.....	.....
.539	.816	.718	.691	SW ...	SW ...	Calm..	2.0	1.0	.0	1.0	S. 45 W	0	0	0	.....	.....
.366	.845	.750	.654	SW ...	SW ...	Calm..	1.0	1.2	.0	0.7	S. 45 W	0	0	0	.....	.....
.594	.782	.682	.686	SW ...	SW ...	Calm..	0.6	3.0	.0	1.3	S. 45 W	0	0	3	.....	.....
.706	.813	.781	767	.....	.....	.....	....	....	....	0.6	N. 22 W	5.7	6.3	6.6	.....	1.41

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1866.					°	°	°	°	°	°	°	°	°				
Jan. 1	29.633	29.506	29.465	29.535	-6	14.5	0.0	-6	15	0.0	03.0	12	10.5	.033	.076	.043	.051
2	29.240	29.154	29.194	29.196	2	18	1	2.5	21	1.5	08.3	22.5	-5	.042	.065	.040	.049
3	29.115	29.070	29.192	29.126	14.5	25	15.5	15	27	16	19.3	28	-3	.078	.112	.082	.091
4	29.374	29.395	29.314	29.361	15	22.5	21	16	24	22.5	20.8	25	12	.074	.103	.086	.091
5	29.192	29.175	29.149	29.172	23	21	11	24	22	11.5	19.2	26	8	.112	.101	.066	.093
6	29.319	29.362	29.456	29.379	17	18	13.5	18.5	19.5	14.5	17.5	25	12	.077	.081	.069	.076
7	29.391	29.266	29.166	29.274	12.5	20	17	13.5	24	18	18.5	23	6	.065	.062	.083	.070
8	29.114	29.137	29.241	29.164	22	21	17	23	23	18	21.3	25	13.5	.107	.090	.083	.093
9	29.246	29.175	29.037	29.153	11	10.5	11	12	12	12	12.0	20	6	.061	.052	.061	.058
10	28.997	28.952	28.974	28.974	10	18	9	11	19.5	10	13.5	22	8	.057	.081	.054	.064
11	29.172	29.292	29.496	29.320	6.5	12	9	7	13	9.5	09.8	14.5	5	.052	.067	.059	.059
12	29.111	29.237	29.395	29.248	9	18	10	19	19.5	11	13.5	21.5	3	.054	.081	.057	.064
13	29.186	29.154	29.332	29.224	11	21	16	12	22.5	17	17.2	24	11	.061	.096	.078	.078
14	29.421	29.339	29.429	29.396	12.5	22.5	13	13.5	24	14	17.2	25	3	.065	.103	.067	.078
15	29.374	29.247	29.156	29.259	-4.5	21	20.5	-4	23	22	13.7	24	-9	.030	.090	.093	.071
16	29.266	29.235	29.400	29.300	5	-1.5	-2.5	5	-1	-1	01.0	23.5	-7	.055	.036	.025	.039
17	29.700	29.018	29.842	29.520	6	10.5	9	6.5	11	9.5	09.0	12.5	-7	.051	.064	.059	.058
18	29.745	29.636	29.581	29.654	8.5	15.5	13.5	9	17	14.5	13.5	17.5	0.0	.058	.071	.089	.073
19	29.516	29.406	29.308	29.410	10.5	22	10	11	24.5	11	15.5	28.5	5	.064	.089	.057	.070
20	29.148	29.092	29.109	29.116	13.5	17	12	14	18	14	15.5	21	2	.074	.083	.052	.070
21	29.181	29.204	29.278	29.221	14.5	13.5	13	15	14.5	14	14.5	19	-2	.078	.069	.067	.071
22	28.999	29.445	29.528	29.324	11	14	11	12	15	12	13.0	16	8	.061	.071	.061	.064
23	29.599	29.639	29.696	29.645	11	17.5	12	12	18.5	13	14.5	20	8	.061	.085	.063	.070
24	29.747	29.729	29.651	29.709	4	20.5	12.5	4.5	21.5	13	13.0	20	1	.046	.098	.076	.071
25	29.458	29.238	29.224	29.307	15	21.5	21.5	15.5	22	22	19.8	25	9.5	.080	.110	.110	.100
26	29.251	29.225	29.796	29.267	13	10	13.5	13.5	10.5	14	12.7	22	9	.072	.062	.074	.069
27	29.468	29.476	29.515	29.486	11	14.5	11	11	15	11.5	12.5	16	8	.071	.078	.066	.072
28	29.408	29.436	29.521	29.455	32	3	-1	35	3.5	-1	23.0	12	-5	.142	.044	.041	.042
29	29.565	29.616	29.625	29.602	-4	-2	-12	-4	-1.5	-12	-05.8	0	-13	.036	.034	.024	.031
30	29.442	29.190	29.120	29.251	-4.5	14.5	17	-4	16	17.5	09.8	21	-23	.030	.065	.098	.031
31	29.097	28.824	28.786	28.902	17.5	26	19	18	27	20	21.7	30.5	6.5	.090	.129	.099	.104
Means.	29.349	29.297	29.349	29.332	10.7	16.6	11.4	11.2	18.0	12.3	13.8	30.5	-23.0	.068	.081	.068	.072
Feb. 1	29.229	29.241	29.190	29.220	16	17	13.5	16.5	17.5	14	16.0	21.5	11	.084	.088	.074	.082
2	28.999	28.890	28.806	28.898	20	32	14	21	35.5	15	23.8	37.5	11	.096	.136	.071	.101
3	28.782	28.784	28.810	28.792	16.5	29	25	17	30.5	26	24.5	35	5	.086	.143	.123	.117
4	28.890	28.921	29.060	28.957	22	31	27	21	34	28.5	27.8	36	18.5	....	.139	.130	.135
5	29.124	29.169	29.237	29.177	17	32	25	18.5	36.5	26	27.0	40	15.5	.077	.123	.123	.108
6	29.322	29.093	29.302	29.239	17.5	33	17.5	18	38	18.5	24.8	41	15	.090	.123	.085	.099
7	29.172	29.010	28.991	29.058	18	40.5	33.5	19.5	41	35	31.8	43	10	.081	.246	.172	.166
8	29.284	29.305	29.390	29.326	14	7	-6.5	14	7.5	-6.5	05.0	22.5	-7	.082	.054	.033	.056
9	29.449	29.445	29.579	29.491	-10.5	-5	-6	-10.5	-5	-6	-07.2	0.0	-17	.027	.034	.033	.031
10	29.761	29.778	29.669	29.736	20	5	2	20.5	6	2.5	09.7	1.0	28	.102	.043	.042	.062
11	29.460	29.462	29.504	29.475	6.5	13	-2	7	14	-1.5	06.5	20.5	-5.5	.052	.067	.034	.051
12	29.298	29.126	29.200	29.208	20	37	33	20.5	38	36	31.5	40	-2	.102	.207	.149	.153
13	29.338	29.413	29.679	29.477	31	23	17	32	24	18	24.7	35.5	15	.162	.112	.083	.119
14	29.866	29.845	29.782	29.831	8	15	3.5	9	16	4	09.7	21	3.5	.051	.074	.045	.057
15	29.662	29.358	28.826	29.282	-6.5	25.5	29	-6	28	30.5	17.5	31.5	-9	.027	.109	.143	.093
16	28.550	28.630	28.996	28.725	25	24	27	27	25.5	28	527.0	3.5	18	.112	.112	.130	.118
17	29.385	29.388	29.334	29.369	19.5	22	10	20	24	11	18.3	29.5	10	.099	.096	.057	.084
18	29.360	29.509	29.667	29.512	9.5	13.5	7	10	15	8	11.0	20.5	5	.080	.063	.048	.057
19	29.665	29.534	29.453	29.551	2	12	12	2	13	13	09.3	20	-2.5	.047	.063	.063	.058
20	29.446	29.500	29.492	29.479	10	15.5	10	10	16.5	10.5	12.3	18	8.5	.068	.076	.088	.078
21	29.457	29.535	29.630	29.541	7	9.5	7	7.5	10	75	08.3	12	5	.054	.080	.054	.063
22	29.643	29.375	29.053	29.357	-14	10.5	16	-14	11.5	16.5	04.7	21	-20	.022	.059	.084	.055
23	28.904	28.961	29.092	28.986	14.5	5	4.5	15	5	5	08.3	21.5	-11	.078	.055	.047	.060
24	29.371	29.353	29.336	29.353	-8	8	-4	-8	9	-4	-01.0	18.5	-13.5	.030	.051	.036	.039
25	29.253	29.228	29.312	29.264	8	22	16	9	24	17	16.7	32	-9	.051	.085	.076	.071
26	29.536	29.447	29.501	29.495	2.5	29.5	22.5	-2.5	33	24	10.7	32	-7	.040	.129	.103	.090
27	29.554	29.371	29.405	29.443	9	36	21.5	10	42	22.5	24.8	44	5	.054	.134	.104	.097
28	29.442	29.369	29.237	29.349	21	21	22	23	22.5	22	22.5	28.5	12	.080	.096	.118	.098
Means.	29.507	29.466	29.483	29.485	9.6	20.1	14.2	10.2	21.9	15.0	15.7	44	-20	.069	.099	.083	.085

the northern and northwestern lakes at Ontonagon, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direct'n.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
1.000	.910	1.000	.970	S	S	S	35	12	4	17.0	South ..	6	0	0	.....	.28
.882	.570	.856	.763	S	S	S	4	12	2	6.0	South ..	0	0	0	.....	.....
.911	.761	.914	.862	S	Calm..	S	12	0	4	4.0	South ..	0	8	0	.....	.....
.899	.803	.794	.809	NE ...	NE ...	NE ...	12	12	12	12.0	N. 45 E.	7	7	0	.....	.....
.868	.860	.901	.876	NE ...	NW...	SE ...	12	25	4	8.0	N. 15 W	0	5	0	.....	.12
.765	.772	.819	.785	W	SW...	NE ...	35	25	35	9.7	N. 76 W	10	8	0	.....	.....
.813	.483	.840	.712	SW...	S	S	4	12	4	6.3	S. 8 W..	7	0	0	.....	.04
.864	.730	.840	.811	N	S	S	25	4	12	3.0	North ..	8	0	0	.....	.08
.804	.706	.804	.771	N	N	N	25	25	25	25.0	North ..	9	10	5	.....	.10
.797	.772	.791	.787	S	S	S	4	4	12	6.7	South ..	10	3	0	.....	.07
.884	.810	.894	.863	S	S	S	4	4	4	4.0	South ..	1	9	0	.....	.60
.791	.772	.797	.787	SE ...	S	NE ...	12	12	25	9.0	S. 84 E .	7	7	8	.....	.04
.804	.794	.834	.811	S	Calm..	NE ...	4	0	25	7.3	N. 53 E.	0	8	3	.....	.28
.813	.803	.816	.811	E	E	W	4	4	12	1.3	West ...	6	9	3	.....	.04
.825	.730	.790	.782	S	S	S	4	4	12	6.7	South ..	0	8	0	.....	.....
1.000	.845	.561	.802	W	W	W	35	75	35	48.3	West ...	8	0	0	.....	.03
.882	.899	.894	.892	NE....	NE....	S	12	4	4	4.7	N. 58 E.	0	0	0	.....	.05
.892	.752	.818	.821	S	S	S	12	12	25	16.3	South ..	0	8	6	.....	.....
.899	.680	.797	.792	SE...	S	SE....	12	2	4	6.0	S. 41 E.	8	3	8	.....	.03
.909	.840	.635	.795	S	N	S	4	12	4	1.3	North ..	0	6	7	.....	.....
.911	.819	.816	.849	NE....	NE....	NE ...	25	4	4	11.0	N. 45 E.	0	0	8	.....	.06
.804	.823	.804	.810	N	NE ...	NE ...	12	4	4	6.0	N. 18 E.	8	9	0	.....	.21
.804	.842	.810	.819	S	S	S	4	4	4	4.0	South ..	0	0	0	.....	.05
.872	.857	.905	.878	S	SW...	S	4	4	4	3.7	S.15 W.	6	8	8	.....	.08
.913	.930	.930	.924	S	NE ...	NE....	4	25	35	19.0	N. 48 E	8	7	0	.....	.....
.907	.898	.909	.905	N	WNW	NW...	35	60	35	38.3	N. 44 W	0	0	0	.....	.14
1.000	.911	.901	.937	WNW	W	SW ..	35	45	75	45.3	S. 73 W	7	7	0	.....	.12
.698	.867	1.000	.865	SW ...	SW ...	SW ...	25	75	35	45.0	S. 45 W	8	8	0	.....	.15
1.000	.839	1.000	.946	W	SW ...	S	25	35	2	18.7	S. 62 W	2	0	0	.....	.04
.825	.239	.919	.828	S	SSE ..	S	4	12	12	9.3	S. 8 E..	0	8	0	.....	.....
.920	.880	.850	.883	S	W	N	4	4	35	10.7	N. 7 W .	8	8	0	.....	.05
.895	.823	.874	.864	.....	.....	.....	....	....	....	4.3	S 79 W.	4.5	5.1	1.9	.....	2.68
.916	.919	.908	.914	NW...	NW...	Calm..	25	12	0	12.3	N. 45 W	0	5	0	.....	.14
.855	.653	.823	.777	S	S	S	12	12	4	9.3	South ..	7	0	0	.....	.06
.917	.839	.876	.077	S	S	S	4	4	4	4.0	South ..	8	0	0	.....	.....
.....	.712	.829	.770	S	S	NE ...	4	12	4	4.7	S. 11 E.	8	5	0	.....	.14
.765	.568	.876	.738	S	W	SW...	4	4	35	13.3	S. 45 W	0	0	0	.....	.....
.920	.537	.842	.766	S	S	S	4	35	12	17.0	South ..	5	2	0	.....	.05
.772	.955	.847	.858	S	S	S	12	2	4	6.0	South ..	0	9	5	.....	.....
1.000	.886	1.000	.995	NW...	NW...	NW...	45	60	45	50.0	N. 45 W	10	10	9	.....	.....
1.000	1.000	1.000	1.000	NW...	W	NW...	45	35	12	28.7	N. 62 W	4	2	0	.....	.10
.926	.760	.862	.849	S	NW...	S	12	12	12	6.0	S. 28 W	0	0	0	.....	.....
.884	.816	.839	.846	S	W	S	12	4	4	5.7	S. 14 W	4	0	0	.....	.18
.926	.905	.705	.845	S	SE....	S	12	4	2	5.7	S. 9 E..	8	7	8	.....	.....
.896	.868	.840	.868	NE ...	NE ...	NE ..	12	35	12	19.0	N. 45 E.	6	7	5	.....	.....
.784	.829	.869	.827	NE ...	W	S	4	12	4	3.3	S. 83 W.	6	3	0	.....	.....
.811	.711	.839	.787	SE....	E	SE....	12	25	25	19.3	S. 63 E .	0	7	8	.....	.....
.761	.812	.829	.801	S	W	NW...	25	35	35	19.7	S. 89 W.	8	8	7	.....	.....
.925	.738	.797	.820	S	S	S	4	4	4	4.0	South ..	7	7	2	.....	.14
.896	.734	.777	.812	NE ...	SE....	NE ...	35	12	4	13.7	N. 62 E	7	6	7	.....	.....
1.000	.810	.810	.873	NE ...	NE ...	NE ...	12	12	4	9.3	N. 45 E .	8	4	6	.....	.11
1.000	.831	.898	.910	NE ...	NE ...	NE ...	4	25	25	18.0	N. 45 E .	8	7	8	.....	.....
.886	.896	.886	.889	NE ...	S	S	25	4	4	6.7	N. 61 E .	8	2	2	.....	.10
1.000	.800	.916	.905	S	S	S	4	25	12	13.7	South ..	0	0	0	.....	.....
.911	1.000	.874	.928	N	N	N	25	12	25	20.7	North ..	4	8	0	.....	.14
1.000	.784	1.000	.928	SW ...	W	S	12	4	4	6.0	S. 45 W .	0	0	0	.....	.....
.784	.738	.834	.785	S	N	S	4	4	4	1.3	South ..	5	0	0	.....	.....
1.000	.654	.803	.819	S	S	S	4	4	4	4.0	South ..	2	0	0	.....	.....
.791	.500	.862	.718	S	W	S	4	4	4	3.0	S. 27 W .	6	0	0	.....	.....
.730	.794	1.000	.841	N	NE ...	SE....	4	25	4	9.3	N. 48 E	0	6	0	.....	.....
.859	.787	.867	.848	.....	.....	.....	....	....	....	1.5	N. 58 W	4.6	3.7	2.4	.....	1.16

Reductions of the monthly meteorological register of the surve

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in inches and mals.
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.
1867.					o	o		o	o	o	o	o	o		
Mar. 1	28.824	28.828	28.924	28.859	35	27	14	35.5	28	14.5	26.0	42	10	.197	.136
2	29.382	29.461	29.446	29.430	–2	5	–8.5	1.5	6	–8	–01.2	20	–13	.034	.043
3	29.351	29.260	29.226	29.279	–1	16.5	8	–10	19	8	05.7	22	–16	.027	.063
4	29.235	29.428	29.440	29.368	1.5	11.5	–3	9	12	–3	06.0	30	– 5	.....	.067
5	29.537	29.685	29.730	29.651	1.5	8.5	–3	2	10	–3	03.0	17.5	–15	.041	.046
6	29.576	29.427	29.414	29.472	9.5	29	26	11	32	27	23.3	35	–10	.049	.126
7	29.477	29.563	29.674	29.571	13	14	6	13	16	6.5	11.8	30	4	.078	.059
8	29.782	29.720	29.678	29.727	–11	20	6	–11	22	6.5	05.8	24.5	–14	.071	.085
9	29.533	29.446	29.346	29.442	9.5	28	17	10	31.5	18	19.8	37.5	– 4	.059	.113
10	28.990	28.859	29.165	29.005	17	32	21	18	32	22	24.0	34	9	.083	.181
11	29.572	29.614	29.483	29.556	1.5	15	–2.5	2	17	–2	05.7	28.5	– 5	.041	.063
12	29.546	29.483	29.412	29.480	–15	12	8	– 0.5	13	8	06.8	21.5	– 7	.031	.063
13	29.433	29.429	29.439	29.434	–7	2.5	0	– 7	2.5	0.5	–01.3	8	–14	.031	.048
14	29.580	29.453	29.468	29.500	–14	7.5	2	–14	9	2	–01.0	16	–18	.022	.043
15	29.467	29.415	29.482	29.455	–10	9.5	–3	–10	11	–2.5	–00.5	19	–18	.027	.049
16	29.480	29.332	29.295	29.369	6	1.6	9	– 6	18	10	07.3	21	–18	.057	.067
17	29.267	29.226	29.238	29.244	–6	6.5	5	– 6	8	1	01.0	12	–10	.033	.040
18	29.269	29.525	29.163	29.319	–9	22	17	– 9	24	19	10.7	26	15	.028	.095
19	29.436	29.142	29.520	29.366	14	21	6	15	24	1	13.3	18	4	.071	.079
20	29.600	29.543	29.579	29.574	7	36	34	7	45.5	34.5	29.0	48	– 3	.059	.095
21	29.451	29.357	29.370	29.393	34	36.5	30	35	37	30.5	34.2	38	19	.183	.209
22	29.427	29.428	29.476	39.444	27	32	32	27	34.5	32.5	31.3	43.5	20	.147	.149
23	29.392	29.330	29.467	29.396	32.5	35	32	33	35	23	30.3	40.5	13	.178	.204
24	29.568	29.547	29.475	29.530	12	18	5	12	18.5	5	11.8	21.2	3	.075	.093
25	29.690	29.712	29.693	29.698	–45	20	6	–45	22	7	–05.3	13	–14	.036	.085
26	29.635	29.523	29.484	29.547	17	–8	20	18.5	33	21	24.2	24	0	.077	.....
27	29.466	29.438	29.456	29.453	12	27	17.5	13	31	19	21.0	34	9	.063	.101
28	29.500	29.448	20.417	29.455	8	22	20	8	24	24	18.7	34	– 1.5	.062	.095
29	29.389	29.268	29.265	29.307	23	36	31	21	41.5	34	32.2	44.5	11	.....	.140
30	29.266	29.171	29.185	29.217	23.5	41	35	21.5	47	39	35.8	50	20	.....	.179
31	29.144	29.022	28.885	29.017	23	40	30	24	44	34	34.0	47	20	.112	.195
Means.	29.442	29.403	29.410	29.418	07.7	20.4	12.0	08.1	24.0	13.9	15.3	50	–18	.071	.097
April 1	28.837	28.929	29.073	28.946	22	35.5	28.5	24	39	30.5	31.2	42	22	.095	.162
2	29.375	29.379	29.328	29.361	21	35	31	21.5	39	36	32.2	44	16	.107	.152
3	29.326	29.341	29.356	29.341	37	40.5	32	38.5	43	33	38.2	47.5	32	.201	.219
4	29.397	29.383	29.366	29.382	37	28.5	24	38.5	30.5	26.5	31.8	40	24	.201	.133
5	29.361	29.310	29.155	29.275	21	36	33.5	22	37	29	29.3	41	20.5	.101	.199
6	28.992	28.982	28.961	28.978	30	43	31	32	37.5	34	34.5	45.5	30	.144	.....
7	29.214	29.239	29.291	29.248	25	35	27	26.5	42	30	32.8	44	26.5	.118	.113
8	29.456	29.528	29.556	29.514	36	31	23	38	35.5	26	33.2	40	20	.186	.122
9	29.533	29.400	29.302	29.412	21.5	39	32.5	22.5	44.5	34	33.7	48	19.5	.104	.166
10	29.347	29.453	29.470	29.423	29	27	30	31	30	23	28.0	31	22	.137	.113
11	29.368	29.169	29.136	29.224	19	40	36	20	47	38.5	35.2	50	14	.092	.156
12	29.137	28.930	28.998	29.022	30	44	44	33	47	46	42.0	49.5	15	.132	.249
13	29.052	29.005	29.125	29.061	38	48	38	37.5	56	40	44.5	64	35	.150	.230
14	29.123	29.031	28.999	29.051	35.5	47	38	37	50	39.5	42.2	51	38	.188	.283
15	29.033	29.147	29.245	29.142	34	38	33	34.5	39	35	36.2	42	41	.189	.216
16	29.299	29.311	29.431	29.347	34	43	38.5	34.5	48.5	40	41.0	49	29	.189	.305
17	29.531	29.585	29.539	29.552	34	44	40	35	48	41	41.3	54	30	.183	.236
18	29.541	29.261	29.215	29.339	39	38.5	45	45	41	48	44.7	54	38	.160	.201
19	29.256	20.212	29.026	29.165	40	52	44.5	42	57	46	48.3	63	39.5	.221	.322
20	28.970	29.193	29.262	29.142	36	38	33	38	39.5	34	37.2	43	32	.186	.210
21	29.271	29.219	29.229	29.240	31	32	28.5	32.5	35	31	32.8	37.5	28	.157	.142
22	29.280	29.341	29.373	29.331	29	31	33	31.5	34	34	33.2	35.5	28	.131	.132
23	29.492	29.465	29.440	29.466	24.5	38	31	23	40	23	32.0	43	18	.....	.200
24	29.484	29.347	29.324	29.400	29	40	32.5	30	43	36	36.3	44	28	.149	.200
25	29.287	29.197	29.002	29.162	31	39	36	32	40.5	39	37.2	43	28	.162	.214
26	28.888	29.266	29.337	29.164	27	29	24	29	30.5	26	28.5	31	24	.124	.149
27	29.375	29.345	29.234	29.318	26	35	30	27	36	34	32.3	40	20	.129	.129
28	29.116	28.967	28.960	29.014	40	51.5	49	47	63.5	54.5	55.0	67	32	.156	.251
29	28.814	28.791	29.167	28.924	43	50.5	33	45	56	34	45.0	58.5	33	.251	.361
30	29.398	29.322	29.240	29.320	27	33	34	28	36.5	36	33.5	38	25.5	.136	.1
Means.	29.252	29.235	29.238	29.242	30.7	38.7	33.8	32.5	42.2	35.6	36.8	67	14	.154	.197

the northern and northwestern lakes at Ontonagon, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.949	.683	.910	.847	S	W.NW	NW ..	12	45	45	27.3	N. 63 W.	7	8	10	.....	.....
.839	.760	.794	.798	N	N	S	12	12	4	6.7	North .	3	2	0	.....	.....
1.000	.616	1.000	.872	S	NE ...	NE ...	4	4	2	2.3	N. 87 E.	8	0	0	.....	.03
.....	.902	1.000	.951	S	NW ..	S	4	24	4	6.7	N. 63 W	6	3	0	.....	.04
.859	.687	1.000	.849	W	SW ..	S	4	60	4	22.0	S. 45 W.	4	0	10	.....	.....
.696	.694	.880	.757	S	S	S	24	24	24	24.0	South .	3	4	10	.....	.....
1.000	.659	.882	.847	W	W.NW	S	24	24	4	15.7	N. 83 W.	3	3	0	.....	.....
1.000	.721	.882	.868	S	N	S	4	4	2	0.7	South .	0	0	0	.....	.....
.894	.639	.840	.791	S	S	S	4	4	4	4.0	South .	3	2	0	.....	.22
.840	1.000	.860	.900	NE ...	NE ...	W	4	2	24	6.7	N. 78 W.	0	0	0	.....	.14
.859	.671	.839	.790	W	W	S	24	4	4	9.7	S. 82 W.	0	2	1	.....	.....
.702	.810	1.000	.837	S	NE ...	NE ...	4	12	2	3.7	N. 60 E	7	2	0	.....	.11
1.000	1.000	.850	.950	W	W	W.SW	45	45	24	37.7	S. 85 W.	0	2	0	.....	.04
1.000	.671	1.000	.890	SW ..	W	S	2	12	4	5.0	S. 68 W.	0	0	0	.....	.....
1.000	.696	.835	.844	S	W	S	4	35	2	12.0	S. 80 W.	2	0	0	.....	.02
1.000	.682	.791	.824	S	W	S	4	12	4	5.0	S. 57 W.	8	2	0	.....	.....
1.000	.660	.850	.837	W	W	S	12	4	4	5.7	S. 76 W.	0	0	0	.....	.....
1.000	.738	.692	.810	S	W	S	4	12	2	4.7	S. 64 W.	0	0	0	.....	.....
.823	.610	.....	.717	W	NW ..	S	12	12	2	7.2	N. 72 W.	7	6	1	.....	.....
1.000	.314	.948	.754	S	S	S	4	12	4	6.7	South .	7	0	3	.....	.02
.898	.931	.947	.932	S	W	SW .	4	2	4	2.7	S. 35 W.	3	8	0	.....	.....
1.000	.744	.945	.896	W	W	SW ..	4	4	4	3.7	S. 67 W.	3	8	0	.....	.06
.946	1.000	.864	.937	S	W.NW	NE ...	4	12	4	3.0	N. 63 W.	7	6	10	.....	.....
1.000	.921	1.000	.974	NE ...	NE ...	Calm..	4	4	0	2.6	N. 45 E	7	0	0	.....	.....
1.000	.721	.769	.830	S	NW ..	S	2	2	2	1.0	S. 27 W.	0	0	0	.....	.....
.765	.....	.855	.810	S	S	S	12	4	4	6.7	South	8	8	0	.....	.....
.810	.582	.768	.720	S	NE ...	S	2	4	2	1.0	S. 66 E	0	0	0	.....	.....
1.000	.738	.483	.740	W	S	S	2	4	4	3.0	S. 13 W.	0	0	0	.....	.....
.....	.534	.712	.623	S	W	S	12	12	4	6.7	S. 37 W.	0	0	0	.....	.....
.....	.554	.636	.595	W	W	S	25	4	12	10.7	S. 68 W.	2	0	0	.....	.....
.868	.677	.617	.721	S	S	S	4	4	2	3.3	South ..	0	0	8	.....	.....
.919	.721	.848	.823	.....	.....	.....	....	....	....	5.7	S 71 W.	3.2	2.1	1.7	.....	.68
.738	.681	.785	.735	S	W	W	4	12	4	5.7	S. 76 W.	0	0	0	.....	.....
.929	.636	.550	.705	S	NE ...	S	2	4	4	1.3	S. 38 E	0	0	6	.....	.....
.860	.791	.893	.848	Calm..	S	Calm..	0	2	0	0.7	South	.....	.....	10	.....	.....
.863	.785	.699	.781	NE ...	NE ...	Calm..	4	12	0	5.3	N. 45 E	8	5	0	.....	.....
.860	.903	.....	.882	Calm..	W	Calm..	0	12	0	4.0	West ..	0	0	0	.....	.....
.794	.....	.712	.753	SW	W	W	12	12	12	11.3	S. 75 W.	2	4	0	.....	.....
.818	.420	.675	.604	S. SW.	NW ..	SW ..	12	4	4	5.0	S. 43 W.	0	0	0	.....	.....
.812	.588	.634	.678	NW ..	W	S	4	12	4	5.0	S. 85 W.	6	0	0	.....	.....
.862	.565	.843	.757	SW ..	W	S	4	12	4	5.0	S. 85 W.	0	0	0	.....	.....
.788	.675	.....	.732	W	NE	Calm..	25	25	0	6.3	N. 23 W.	1	4	0	.....	.....
.850	.483	.768	.700	S	W	S	2	12	2	4.3	S. 72 W.	0	0	0	.....	.....
.703	.772	.843	.773	S	NE ...	S	4	12	12	3.7	S. 47 E	0	0	0	.....	.....
.669	.512	.820	.667	S	W	SW ..	2	4	4	2.7	S. 53 W.	0	1	8	.....	.....
.850	.786	.863	.834	S	N	N	4	4	2	0.7	North .	7	8	0	.....	.08
.948	.907	.797	.984	W	NW ..	S	4	2	2	1.7	S. 83 W.	.....	.....	.....	.....	.04
.948	.602	.864	.805	S	W.NW	W	2	4	12	2.7	S. 86 W.	0	0	0	.....	.....
.898	.704	.912	.838	W	W	S	12	12	2	8.3	S. 85 W.	0	0	4	.....	.....
.533	.781	.777	.697	S	S	S	35	35	12	27.3	South .	7	7	7	.....	.....
.829	.692	.882	.801	SW ..	W	W	4	12	12	9.0	S. 84 W.	0	0	7	.....	.....
.811	.861	.895	.856	SW ..	W	W	12	25	12	15.3	S. 79 W.	3	8	7	.....	.06
.848	.698	.736	.761	W	NW ..	S	4	12	2	4.7	N. 63 W.	7	6	3	.....	.....
.740	.712	.895	.782	N	N	Calm..	25	12	0	12.3	North .	8	3	0	.....	.....
.....	.820	.800	.810	S	N	S	4	4	2	0.7	South	1	0	0	.....	.....
.890	.750	.656	.766	SW ..	NW ..	S	2	12	2	3.7	N. 63 W.	0	0	2	.....	.....
.896	.866	.726	.829	S	SW ..	N	2	12	4	3.7	S. 54 W.	2	7	0	.....	.....
.775	.839	.754	.789	N. NE	N	S	35	25	2	19.0	N. 14 E	7	7	0	.....	.12
.880	.900	.617	.799	W.NW	SW ..	S	4	12	4	5.7	S. 47 W.	3	0	6	.....	.....
.483	.380	.647	.505	S	S. SW	S	4	35	25	21.0	S. 12 W.	0	0	3	.....	.....
.840	.684	.895	.806	S	S	N	35	2	35	0.7	South .	4	7	0	.....	.40
.683	.661	.802	.715	N	W	W	4	12	4	5.7	N. 76 W.	4	0	8	.....	.12
.807	.708	.776	.763	.....	.....	.....	....	....	....	3.3	S. 72 W.	2.4	2.4	2.4	.....	.77

Reductions of the monthly meteorological register of the survey of

		Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.		
						Wet bulb, or point of evaporation.			Dry bulb or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U. S. inches and decimals.	
		7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.
						°	°	°	°	°	°	°	°	°		
1867.																
May	1	29.343	29.441	29.524	29.439	22.5	33.5	24.5	25	34.5	28	29.2	36	22	.092	.179
	2	29.615	29.590	29.479	29.558	19	31	25.5	30.5	33	30	27.8	36	18	.086	.15
	3	29.347	29.274	29.172	29.264	20	42	34	34	47	35	35.3	51	24	.062	.2
	4	28.904	28.937	28.891	28.911	38	38	33.5	39	40	40	39.7	46	32	.216	.2
	5	29.293	29.062	29.389	29.094	33.5	38	31.5	36	39.5	32	35.8	11	32.5	.134	.1
	6	29.421	29.337	29.240	29.340	31	33	32	34.5	42	34.5	34.0	48.5	32	.164	.1
	7	29.246	29.371	29.345	29.376	32	40	30	33	42	33	36.3	61	31	.155	.1
	8	29.131	29.192	29.207	29.215	30.5	38.5	35	39	45	39.5	40.0	51	24	.112	.2
	9	29.348	29.184	29.246	29.187	38	37	40	38	45	40	39.0	45	34.5	.216	.2
	10	29.448	29.360	29.334	29.347	38	38	43.5	40	50	43	42.0	51	28	.20	.2
	11	29.497	29.444	29.491	29.461	38	38	44.5	43.5	49.5	43	41.7	52	32	.21.5	.1
	12	29.227	29.412	29.352	29.430	38	38	43.5	34	48	38	44.0	61.5	35		
	13	29.085	29.170	29.177	29.211	34	38	37.5	35	40	36.5	39.7	46	38		
	14	29.167	29.003	29.063	29.205	32	38	40.5	35	53	37	41.5	52	28		
	15	29.264	29.223	29.225	29.292	35	38	42	34	47	36	37.2	46	27		
	16	29.439	29.277	29.334	29.503	38	38	43	34	48	37	40.5	55	32		
	17	29.607	29.499	29.570	29.554	31	37	41.5	46	47	47	44.5	54	36		
	18	29.405	29.541	29.514	29.326	37	36	40	39	47	47	42	56.5	37		
	19	29.376	29.376	29.378	29.334	36	37	40	40	47	42	42	52	37		
	20	29.325	29.320	29.305	29.281	37	44	40.5	39.5	47	44	42.7	52.5	37		
	21	29.221	29.240	29.259	29.208	36.5	47	41.5	37	47	46.5	42.5	52.5	37		
	22	29.148	29.218	29.185	29.088	43.5	46	45	39.5	47	48	43.5	49	41		
	23	28.959	29.047	29.099	28.962	37	37	40	37	47	37.5	40.5	52.5	36		
	24	29.035	28.957	28.971	29.003	39	46	47	39.5	53	47	46.5	59	41		
	25	29.289	29.013	29.102	29.306	39	46	40	41	47.5	52	47.5	59	40.5		
	26	29.392	29.269	29.361	29.379	40	45	47.5	41	49.5	52	49	59	43		
	27	29.348	29.258	29.386	29.299	41	48	44	42	52	59	50.5	59	50.5		
	28	29.258	29.290	29.260	29.263	40	45	48.5	52							
	29	29.506	29.244	29.247	29.474	47	54									
	30	29.468	29.526	29.390	29.406											
	31		29.395	29.355												
Means..		29.288	29.277	29.289	29.285	35.3	41.7	37.9	37.1	45.4	39.8	40.8				
June	1	29.282	29.112	28.974	29.123	50	49.5	49.5	53	53	50	46.5	52.0			
	2	29.033	28.791	28.839	28.888	42	41.5	44.5	41.5	53	46.5	53.5	43.0			
	3	28.962	28.971	29.066	29.006	51	61.5	52	53	55	53.5	53.5	59			
	4	29.312	29.340	29.278	29.310	43	49	51	53	64.5	55.5	54	50.5			
	5	29.225	29.054	29.097	29.095	56.5	66	45.5	46	60	54	54	59			
	6	28.937	29.044	29.007	29.026	45	49	53	47	64	53	54.5	54.5			
	7	29.208	29.190	29.216	29.211	46.5	49	67	64	72.5	70	70	64			
	8	29.148	29.209	29.364	29.337	62	77	64.5	66	87	77	67	69			
	9	29.363	29.263	29.314	29.313	66	65	59.5	64.5	77	72	69	69			
	10	29.313	29.228	29.176	29.239	62	59	64	66	77	76	70.5	48			
	11	29.062	29.043	29.137	29.081	61	67	54.5	53	72	70.5	65.5	67			
	12	29.314	29.364	29.422	29.367	50	65.5	47	57	56	64.5	56.5	58			
	13	29.423	29.201	29.071	29.232	54.5	68	64	55.5	54	55	55	52			
	14	29.194	29.187	29.129	29.170	55	64	54	54	57	50	50	61			
	15	29.257	29.173	29.253	29.228	52	59	52.5	54	60	65	57.5	68			
	16	29.421	29.390	29.273	29.361	51	51	49.5	60	61	57.5	54	82.5			
	17	29.129	29.114	29.276	29.415	58	60.5	59.5	51	66	59	60	71			
	18	29.420	29.378	29.447	29.476	54.5	51.5	52	57	67.5	60	67.5	77			
	19	29.487	29.458	29.466	29.450	55	60	57.5	54	68	82.5	71	86.5			
	20	29.455	29.427	29.469	29.286	62	71	58.5	59	77	71	77				
			29.224	29.261	29.344	55	62	70.5	65	82.5	86.5	74				
					29.236	55	73	67.5	61	86.5	77	77				

the northern and northwestern lakes at Ontonagon, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation=1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.684	.896	.599	.726	N.....	W....	N.....	45	12	35	27.0	N. 9 W	7	0	3	.....	.....
.780	.800	.836	.805	N.....	N.....	E.....	2	12	12	6.3	N. 39 E	0	0	0	.....	.....
.483	.624	.847	.651	S.....	E.....	SE....	12	25	25	17.3	S. 55 E	0	6	0	.....	.....
.907	.820	1.000	.909	E.....	W....	S.....	2	2	2	0.7	South..	8	0	2	.....	.53
.435	.863	.896	.731	SW...	W....	NW...	12	25	35	29.3	N. 74 W.	3	5	0	.....	.....
.948	.705	.744	.799	NW...	N.....	NW...	35	12	12	18.7	N. 36 W.	6	3	8	.....	.....
.792	.661	.703	.719	N.....	N.....	N.....	4	4	2	3.3	North..	7	0	0	.....	.....
.543	.607	.773	.641	S.....	N.....	NE....	4	4	4	1.3	N. 45 E	3	2	0	.....	.....
.907	.202	.900	.836	SE....	NE....	S.....	12	4	4	5.0	S. 49 W.	8	4	0	.....	.....
.905	.607	.750	.754	W.....	W.NW	W.....	12	4	12	9.0	N. 87 W.	2	3	0	.....	.....
.863	.548	.849	.753	W.....	N.....	S.....	4	4	4	1.3	West..	6	0	0	.....	.....
.744	.642	.666	.684	S.....	N.....	S.....	2	12	12	0.7	South..	0	3	0	.....	.....
.738	.776	.719	.744	W.....	N.....	S.....	4	12	4	3.0	N. 27 W.	4	6	7	.....	.....
.898	.765	.853	.772	N.....	N.....	S.....	2	25	2	8.3	North..	0	0	0	.....	.....
.834	.645	.807	.762	N.....	N.....	N.....	2	12	2	5.3	North..	0	0	0	.....	.....
.762	.563	.802	.709	SW...	N.....	N.....	4	12	4	4.7	N. 9 W.	2	2	7	.....	.....
.738	.698	.712	.716	S.....	NW...	S.....	2	4	4	1.3	S. 38 W.	2	2	0	.....	.....
.896	.589	.923	.803	S.....	N.....	NE....	2	12	12	6.7	N. 25 E	0	0	0	.....	.....
.905	.641	.847	.798	NE....	NE....	NE....	4	25	12	13.7	N. 45 E	3	7	7	.....	.....
.773	.829	.744	.782	N.....	N.....	NE....	4	25	12	12.7	N. 13 E	6	4	7	.....	.....
.726	.716	.907	.783	NE....	NE....	NE....	4	25	12	13.7	N. 45 E	0	4	2	.....	.....
.732	.807	.692	.744	NE....	NE....	NE....	12	4	2	6.0	N. 45 E	0	2	1	.....	.....
.742	.633	.710	.695	NW...	NW...	Calm..	12	25	0	12.3	N. 45 W.	0	0	7	.....	.....
.824	.850	.826	.853	Calm..	NW...	NW...	0	4	2	2.0	N. 45 W.	9	8	0	.....	.....
1.000	.952	1.000	.984	NW...	N.....	Calm..	45	60	0	32.3	N. 19 W.	10	9	0	.....	.33
.954	.923	.912	.930	Calm..	NW...	Calm..	0	12	0	4.0	N. 45 W.	3	6	0	.....	.21
.824	.544	.853	.740	NE....	NE....	Calm..	2	35	0	12.0	N. 45 E	0	3	0	.....	.....
.869	.811	.955	.878	NW...	SE....	N.....	2	25	25	6.3	N. 62 E	8	9	9	.....	.....
.956	.727	.889	.737	Calm..	SW...	NW...	0	25	12	9.3	S. 71 W.	9	3	7	.....	.32
.829	.676	.930	.808	N.....	N.....	Calm..	4	2	0	2.0	North..	0	0	0	.....	.....
.660	.703	.857	.740	N.....	N.....	Calm..	4	12	0	5.3	North..	6	7	1	.....	.....
.797	.720	.823	.780	.....	.....	.....	....	....	....	4.2	N. 5 W	3.6	2.9	2.2	.....	1.38
.798	.765	.963	.842	E.....	N.....	Calm..	4	25	0	8.7	N. 9 E..	9	9	10	.....	.....
.....	.....	.845	.845	NE....	SW...	W....	25	25	35	11.7	West...	10	10	10	.....	.39
.864	.573	.899	.779	Calm..	W....	NE....	0	25	2	7.7	N. 87 W.	0	2	1	.....	.10
.878	.762	.839	.826	NE....	NE....	Calm..	12	4	0	5.3	N. 45 E.	1	0	0	.....	.....
.578	.....	.802	.690	E.....	NE....	NW...	12	4	12	4.3	N. 29 E	1	8	10	.....	.....
.921	.733	.620	.758	SW...	N.....	W....	12	25	2	6.7	N. 33 W.	8	8	9	.....	.....
.656	.647	.901	.735	Calm..	NE....	NW...	0	45	25	17.0	N. 16 E.	10	1	8	.....	.75
.888	.618	.848	.785	NE....	SE....	SE....	12	12	12	9.0	S. 71 E	0	5	0	.....	.....
.692	.751	.867	.770	SE....	NE....	SE....	25	35	12	17.0	S. 82 E	0	7	2	.....	.....
.862	.828	.753	.814	E.....	Calm..	E.....	4	0	25	9.7	East....	8	9	2	.....	.20
.735	.569	.747	.684	E.....	SW...	S.....	12	25	25	14.3	S. 7 W	1	5	3	.....	.08
.798	.690	.329	.606	SW...	S.....	SW...	4	2	4	3.0	S. 35 W.	2	3	1	.....	.....
.843	.644	.925	.804	SE....	E.....	SE....	2	35	45	26.3	S. 60 E.	9	8	9	.....	.....
.935	.683	.841	.820	S.....	S.....	S.....	2	4	2	2.7	South..	9	3	5	.....	.83
.776	.703	.842	.774	W.....	W....	Calm..	12	12	0	8.9	West....	0	0	0	.....	.....
.802	.743	.669	.738	SW...	NE....	N.....	4	35	4	11.0	N. 40 E	0	2	7	.....	.....
.880	.927	.827	.878	S.....	W....	W.....	4	25	12	12.7	S. 84 W.	4	9	3	.....	.26
.894	.757	.883	.845	W.....	W....	E.....	12	25	4	11.0	West...	2	0	5	.....	.05
.814	.834	.867	.838	S.....	NE....	S.....	2	4	4	1.3	S. 38 E.	3	4	0	.....	.....
.874	.601	.833	.769	S.....	S.....	S.....	12	12	4	9.3	South..	4	4	5	.....	.12
.717	.544	.799	.687	S.....	S.....	S.....	25	4	4	11.0	South..	3	3	0	.....	.....
.761	.576	.909	.749	W.....	W....	S.....	2	4	2	2.3	S. 73 W.	0	0	0	.....	.....
.708	.499	.941	.716	S.....	S.....	S.....	12	12	4	9.3	South..	3	7	5	.....	.....
.817	.710	.945	.824	S.....	S.....	S.....	25	12	4	13.7	South..	2	8	4	.....	.18
.828	.698	.886	.804	S.....	SE....	W....	25	12	25	12.3	S. 26 W.	2	8	4	.....	.16
.772	.681	.....	.730	S.....	S.....	Calm..	12	12	0	8.0	South..	0	6	5	.....	6
.963	.747	.847	.852	E.....	W....	W.....	12	25	12	8.3	West....	5	0	0	.....	.48
.713	.694	.783	.730	W.....	W....	S.....	4	4	4	3.0	S. 63 W.	0	1	0	.....	.....
.729	.764	.744	.746	SW...	SW...	S.....	12	2	12	8.0	S. 24 W.	3	0	2	.....	.....
.783	.751	.886	.807	S.....	W....	S.....	2	25	12	9.7	S. 29 W.	0	3	2	.....	.....
.754	.696	.856	.775	.....	.....	.....	....	....	...	2.2	S. 9 W.	3.3	4.4	3.7	.....	3.66

Reductions of the monthly meteorological register of the surve

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.		
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.							
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	Elasticity, in I inches and d mals.	
														7 a. m.	2 p. m.
1867.					o	o	o	o	o	o	o	o	o		
July 1	29.283	29.232	29.188	29.234	56	67	66	60	75	69.5	68.2	....	58	.396	.554
2	29.157	29.163	29.193	29.171	66	71	67	69.5	77	70	72.2	....	67.5	.592	.678
3	29.173	29.188	29.171	29.177	65.5	58	53	68	80	54	60.7	....	53.8	.585	.456
4	29.217	29.221	29.175	29.204	52	57	55	54	60.5	58	57.5	....	55.5	.362	.419
5	29.186	29.103	29.128	29.139	59	61.5	63	61	66	65	64.0	....	59.5	.473	.486
6	29.229	29.124	29.111	29.155	53	64.5	60	55.5	71	63	63.0	....	51.2	.370	.519
7	29.335	29.350	29.404	29.363	57	57.5	52.5	61	66	56	61.0	....	50	.419	.361
8	29.309	29.264	29.483	29.352	49	60	53	53	64.5	57	58.3	....	44.0	.295	.458
9	29.493	29.271	29.276	29.347	51	62	61	54	71.5	66	63.8	....	58	.335	.429
10	28.894	28.982	28.930	28.935	44.5	71	61.5	48.5	75	65	62.8	....	50	.247	.704
11	29.117	29.409	29.444	29.323	58.5	55	50	61.5	57.5	51.5	56.8	....	54	.446	.400
12	29.497	29.448	29.430	29.458	52.5	60.5	55	55	64	57	58.7	....	59	.363	.479
13	29.421	29.312	29.325	29.353	60	76.5	59.5	64.5	82	62	69.5	....	55	.456	.869
14	29.250	29.107	29.023	29.127	61.5	69.5	66	66.5	81.5	68	72.0	....	54.5	.479	.559
15	29.280	29.348	29.416	29.348	56	59	57.5	57.5	66	59	60.8	....	60.5	.429	.407
16	29.430	29.422	29.397	29.416	55	60.5	42	58	68	65.5	63.8	....	35	.393	.427
17	29.392	29.345	29.327	29.355	58.5	66	55	65.5	79.5	58	67.7	....	52.5	.398	.454
18	29.341	29.300	29.293	29.311	59.5	67.5	63	66	77	68.5	70.5	....	63.5	.422	.546
19	29.364	29.365	29.425	29.385	61.5	65	64.5	67	70.5	67	68.2	....	60	.473	.546
20	29.477	29.419	29.402	29.433	63	66	54.5	65	70.5	61	65.5	....	58	.549	.575
21	29.380	29.195	29.225	29.267	65	70	68	70.5	77	72	73.2	....	64	.444	.636
22	29.239	29.311	29.195	29.248	69	73	71	73	83	76	77.3	....	70.5	.655	.677
23	29.222	29.208	29.243	29.224	73	73	72.5	78	78.5	76.5	77.7	....	67.5	.744	.75
24	29.280	29.245	29.235	29.253	66.5	65	68.5	68	70	76	71.3	....	54	.630	.556
25	29.254	29.229	29.223	29.235	58	64.5	65	60.5	71	68	66.5	....	58.5	.449	.515
26	29.223	29.157	29.060	29.127	62	68	69	65.5	72	72	69.8	....	68	.509	.63
27	28.975	28.969	28.910	28.951	64	76	71	68	81	72.5	73.8	....	52.5	.543	.82
28	28.966	29.137	29.379	29.194	64	60	51	70.5	64	53	65.8	....	48	.509	.46
29	29.467	29.454	29.457	29.459	55	67	62	60	70.5	64.5	65.0	....	58	.367	.61
30	29.428	29.343	29.091	29.287	61	63	59	65	65.5	60	63.5	....	56	.480	.54
31	29.073	29.025	29.041	29.046	56.5	62.5	60.5	58.5	68	62.5	63.0	....	68	.430	.49
Means . . .	29.269	29.247	29.242	29.253	59.2	65.1	60.6	62.8	71.1	64.3	66.1	....	35	.459	.55
Aug. 1	29.100	29.158	29.234	29.197	58	63	60	60	69	63	64.0	....	57.5	.456	.49
2	29.386	29.353	29.366	29.368	55	64	60	57	68.5	61	62.2	....	56	.407	.53
3	29.311	29.364	29.290	29.288	60.5	78	66	64	80.5	67.5	70.7	....	65	.480	.92
4	29.371	29.406	29.417	29.398	62	66	63	66	73.5	65	68.2	....	63.5	.502	.53
5	29.424	29.380	29.350	29.385	65.5	72.5	68	70	71	71	70.7	....	51.5	.568	....
6	29.367	29.289	29.314	29.323	70	76	77.5	72.5	83.5	79	78.3	....	69.5	.699	.79
7	29.350	29.289	29.267	29.302	72	73	70	75	76.5	72	74.5	....	70.5	.744	.77
8	29.254	29.110	29.190	29.185	71.5	79.5	71	75	93	73	80.3	....	71	.794	.82
9	29.384	29.424	29.478	29.429	57	64	59	61	70	61	64.0	....	61	.412	.51
10	29.586	29.545	29.506	29.546	53	67	64	55	76	65	65.3	....	50	.376	.54
11	29.478	29.291	29.195	29.321	57	75	68	60	78.5	72.5	70.3	....	68	.426	.82
12	29.074	29.124	29.205	29.134	66	68	61	68	69.5	64	67.2	....	63	.612	.66
13	29.263	29.189	29.101	29.184	56	68	60	57	73	63	64.3	....	62	.436	.61
14	29.242	29.425	29.470	29.379	55.5	66.5	59	57	70.5	59	62.2	....	51	.413	.59
15	29.527	29.461	29.350	29.446	55	68.5	62	57	73	64	64.7	....	45	.407	.63
16	29.340	29.213	29.079	29.211	62	71	71	67	80	73.5	73.5	....	62	.489	.63
17	29.054	28.994	28.892	28.980	69	72	60	73.5	77	62	70.8	....	62	.648	.70
18	29.246	29.290	29.305	29.280	58	63	65	60	65	67	64.0	....	58	.456	.54
19	29.413	29.366	29.404	29.394	53	62.5	59	54	70	61	61.7	....	50	.389	.46
20	29.391	29.362	29.347	29.367	55.5	73	67	57	77	69	67.7	....	53	.421	.75
21	29.304	29.294	29.211	29.270	64.5	72	65	67	76	68	70.3	....	67	.573	.50
22	29.113	29.057	29.007	29.059	65.5	70	71.5	68	74.5	73	71.8	....	62	.595	.67
23	29.151	29.202	29.280	29.211	62	61.5	61	65	74	62	67.0	....	61	.516	.92
24	29.420	29.404	29.374	29.399	49.5	66	57	52	71	59	60.7	....	44	.321	.57
25	29.366	29.344	29.361	29.357	60	73	65	64	80.5	69	71.2	....	55.5	.465	.7
26	29.301	29.250	29.214	29.255	60	81.5	64.5	65	86	66	72.3	....	55	.451	.1
27	29.193	29.188	29.092	29.158	65.5	72	62	69	77	66	70.7	....	66	.59	.18
28	29.165	29.235	29.299	29.233	57	59	60	62	64	62	62.7	....	56	.399	.37
29	29.420	29.492	29.478	29.460	50	45.5	45	52.5	58.5	54	55.0	....	45.5	.328	.222
30	29.365	29.316	29.262	29.311	44.5	64	57	47.5	74	60	60.5	....	45	.254	.462
31	29.237	29.379	29.442	29.353	52	49	40	53	54.5	43	50.2	....	41	.375	.275
Means . . .	29.311	29.296	29.283	29.296	59.4	67.9	62.6	62.4	73.7	65.0	67.0	....	41	.482	.569

the northern and northwestern lakes at Ontonagon, Michigan.

VAPOR.				WIND.							Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
.765	.639	.822	.742	S	N	W	4	2	4	1.6	S. 66 W.	3	2	4	.....	.....
.822	.731	.848	.800	S	N	S	12	2	12	7.3	South ...	1	2	3	.....	.....
.869	.880	.973	.894	S	S	NE ...	4	4	12	2.7	N. 86 E..	3	10	0	.....	.....
.867	.795	.816	.826	W	N	S	4	4	4	1.3	West....	0	2	3	.....	.52
.882	.761	.890	.844	SW ...	SW ...	S	2	4	4	3.0	S. 27 W	6	8	0	.....	.....
.839	.625	.831	.785	S	E	W	4	25	45	7.0	S. 79 W.	4	6	8	.....	.....
.769	.564	.778	.704	W	W	S	25	12	2	12.7	S. 87 W.	0	0	4	.....	.10
.733	.755	.752	.747	W	W	S	12	25	4	12.7	S. 84 W.	4	0	0	.....	.....
.802	.556	.735	.698	S	NW...	SE....	4	12	4	2.0	N. 73 W	0	1	9	.....	.....
.706	.812	.809	.776	SW ...	SW ...	SW ...	25	35	45	35.0	S. 45 W	7	8	0	.....	.59
.826	.844	.895	.855	NW...	NW...	Calm..	60	12	0	24.0	N. 45 W	4	8	0	.....	.....
.837	.806	.844	.829	Calm..	NW ...	SW ...	0	4	2	1.6	N. 70 W	0	0	0	.....	.....
.755	.767	.856	.793	SE....	SE....	SE....	12	25	2	13.0	S. 45 E..	0	0	0	.....	.....
.737	.521	.895	.718	SE....	SE....	SE....	25	45	45	38.3	S. 45 E..	3	8	0	.....	.....
.906	.636	.908	.817	NW...	NW...	NW...	25	35	2	20.7	N. 45 W.	0	3	1	.....	1.23
.816	.624	.....	.720	N	W	SE....	2	4	12	2.7	N. 34 E..	0	5	0	.....	.....
.634	.455	.816	.635	SE....	SE....	S	25	35	4	21.0	S. 42 E..	7	8	3	.....	.....
.660	.588	.721	.656	S	S	S	35	25	12	24.0	South ...	7	7	4	.....	.....
.715	.729	.867	.770	S	N	S	12	4	4	4.0	South ...	7	2	0	.....	.....
.890	.776	.632	.766	S	NE ...	S	4	4	2	1.3	N. 40 E..	0	0	0	.....	.....
.729	.689	.804	.741	Calm..	NE ...	S	0	60	4	19.0	N. 48 E..	0	0	0	.....	.....
.807	.600	.771	.759	W	W	Calm..	4	4	0	2.7	West....	0	0	0	.....	.....
.776	.758	.816	.783	S	W	S	4	12	4	5.0	S. 56 W	3	3	2	.....	.....
.920	.751	.664	.778	N	NE	S	2	25	2	8.3	N. 45 E..	0	2	4	.....	.....
.852	.685	.843	.793	NE	NE	S	4	12	4	4.6	N. 57 E..	0	0	0	.....	.....
.811	.804	.852	.822	S	NW...	S	4	4	2	13.0	S. 6 W..	0	0	0	.....	.....
.793	.794	.925	.834	S	W	S	35	4	4	13.0	S. 6 W..	3	3	0	.....	.....
.683	.780	.864	.776	W	W	W	12	35	4	17.0	West....	4	4	0	.....	.20
.708	.824	.862	.798	W	SW ...	S	25	12	12	13.0	S. 59 W.	1	0	0	.....	.....
.783	.864	.940	.862	S	SW ...	SE....	12	4	12	8.0	S. 14 W	5	10	8	.....	.....
.877	.720	.885	.827	W	W	W	60	25	12	32.3	West....	8	5	8	.....	.62
.793	.716	.829	.779	.....	.....	.....	....	....	....	4 5	S. 37 W	2.6	3.5	2.0	.....	3.26
.880	.700	.831	.804	W.NW	W	NW...	25	25	25	23.7	N. 67 W.	4	2	0	.....	.....
.874	.770	.941	.862	NE	NE	S	4	12	2	5.0	N. 51 E..	3	0	0	.....	.....
.806	.889	.920	.872	S	S	S	4	4	4	4.0	South ...	6	4	7	.....	.....
.786	.653	.890	.776	SW ...	W	S	12	12	4	8.0	S. 59 W.	5	0	0	.....	.10
.774	.....	.851	.812	SE....	W	S	12	4	4	4.3	S. 20 E..	0	7	3	.....	.....
.877	.694	.931	.834	S	S	Calm..	2	12	0	4.7	South ...	5	2	3	.....	.....
.858	.860	.900	.873	S	NE	N	4	12	4	4.0	N. 45 E..	3	4	3	.....	.....
.835	.532	.942	.756	S	S	S	12	25	4	13.7	South ...	0	0	0	.....	.....
.769	.704	.882	.785	NW...	NW...	NW...	12	12	4	9.3	N. 45 W.	0	0	0	.....	.72
.869	.603	.944	.805	S	W	S	4	4	4	3.0	S. 27 W.	0	0	0	.....	.....
.822	.842	.783	.816	S	S	S	12	12	12	12.0	South ...	0	0	4	.....	.....
.895	.922	.833	.883	SW ...	W	Calm..	12	12	0	7.3	S. 67 W.	6	5	3	.....	.55
.936	.761	.831	.843	S	S	S	4	4	4	4.0	South ...	0	0	0	.....	.....
.904	.800	1.000	.901	Calm..	W	S	0	4	2	1.7	S. 67 W.	0	0	0	.....	.....
.874	.784	.888	.849	S	NE	S	2	2	4	1.7	S. 17 E..	0	0	0	.....	.....
.740	.623	.879	.747	S	S	W	12	25	12	13.0	S. 18 W	4	6	0	.....	.....
.786	.774	.884	.815	S	W	S	12	12	12	9.0	S. 27 W	4	2	4	.....	.....
.880	.890	.893	.888	NE	NE	Calm..	12	4	0	5.3	N 45 E..	5	0	0	.....	.....
.933	.635	.882	.817	S	S	S	2	12	4	6.0	South ...	0	0	0	.....	.....
.905	.817	.896	.873	S	S	S	4	2	4	3.3	South ...	0	3	0	.....	.....
.867	.786	.843	.832	S	NE	NW...	4	4	4	0.5	North ...	0	4	0	.....	.....
.869	.798	.926	.861	S	W	NW...	12	12	12	7.0	S. 81 W.	7	5	0	.....	.....
.836	.452	.942	.743	W	W	W	25	12	4	13.7	West....	0	0	0	.....	.04
.827	.754	.878	.820	S	W	W	12	4	2	4.7	S. 27 W	0	0	0	.....	.....
.780	.683	.796	.753	S	W	S	4	4	2	2.7	S. 33 W.	1	5	0	.....	.....
.731	.816	.918	.822	S	NE	S	4	4	4	2.0	N. 29 E..	0	0	0	.....	.....
.820	.774	.786	.793	S	W	W	4	12	25	12.7	S. 84 W.	8	4	0	.....	.....
.718	.727	.884	.776	W	W	W	45	25	35	38.3	West....	0	4	2	.....	.12
.829	.263	.434	.508	N	W	S	12	25	4	9.0	N 71 W.	4	0	0	.....	.....
.774	.551	.822	.716	S	SW ...	W	4	12	2	5.3	S. 39 W.	0	2	5	.....	.....
.932	.647	.767	.782	NE	NE	NE	45	25	4	24.7	N. 45 E..	8	3	0	.....	.1
.838	.726	.830	.807	.....	.....	.....	....	....	....	3.7	S. 65 W.	2.4	2.0	1.1	.....	1.65

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum	Minimum.	Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Sept. 1	29.298	29.402	29.308	29.336	53	57	46	55	63	48	55.3	....	33	.376	.386	.284	.382
2	29.118	29.080	29.093	29.097	47	57	46	49	59	49	52.3	....	44	.297	.439	.271	.336
3	29.006	29.170	29.229	29.135	46	55	47	50	58	48.5	52.2	....	46	.256	.393	.303	.318
4	29.217	29.121	29.045	29.128	47	75	61	49	77	64.5	63.5	....	42	.297	.641	.490	.543
5	28.791	28.991	29.151	28.978	65.5	54	47	70	55.5	48.5	58.0	....	48	.568	.398	.303	.423
6	29.319	29.431	29.597	29.449	45	50.5	42	47	58.5	43	49.5	....	40	.273	.392	.254	.263
7	29.635	29.504	29.382	29.507	43	64	54	46	73	60	59.7	....	60	.238	.476	.338	.351
8	29.265	29.199	29.213	29.202	53	57	54	54.5	58.5	55	56.3	....	53	.393	.446	.338	.439
9	29.345	29.436	29.489	29.423	44.5	48.5	44.5	47	54	53.5	51.3	....	46	.261	.369	.182	.271
10	29.506	29.333	29.294	29.378	46.5	61.5	50	48.5	65.5	53	55.7	....	46	.240	.492	.321	.351
11	29.121	29.033	29.041	29.065	52	61.5	65	54.5	69	67.5	63.7	....	61	.355	.446	.564	.462
12	29.204	29.170	29.177	29.184	54	53.5	51	55.5	56	53	54.8	....	52	.398	.377	.348	.374
13	29.335	29.421	29.504	29.420	50	50	37	52	59.5	38.5	50.0	....	38.5	.334	.415	.201	.257
14	29.177	29.394	29.302	29.291	51	56	53.5	53	59	56	56.0	....	51	.348	.409	.377	.378
15	29.210	29.087	29.003	29.100	56	65	68	57	67	69.5	64.5	....	57	.436	.491	.665	.564
16	29.073	29.177	29.286	29.179	71	74	74	74.5	81	77.5	77.7	....	67	.711	.745	.792	.749
17	29.286	29.387	29.473	29.382	73	55	54	76	56	55	62.3	....	54	.771	.420	.404	.532
18	29.619	29.615	29.590	29.608	50.5	56	49	52	62	51	55.0	....	47	.347	.369	.321	.346
19	29.337	29.204	29.317	29.286	55	65	53.5	56	62	54	57.3	....	49	.430	.....	4 3.	.472
20	29.279	29.543	29.590	29.471	52	58	49	54.5	62	52	56.2	....	50	.355	.429	.308	.364
21	29.505	29.526	29.403	29.478	49	59.5	55	51	63.5	58	57.5	....	45.5	.321	.456	.393	.390
22	29.548	29.579	29.631	29.586	56	56.5	48.5	58.5	58	50.5	55.7	....	50	.416	.437	.315	.389
23	29.640	29.502	29.402	29.515	51	68	60	53	68.5	65	62.2	....	48	.348	.678	.451	.492
24	29.310	29.338	29.406	29.351	59	64.5	56	64.5	67	57.5	63.0	....	56	.427	.573	.429	.476
25	29.688	29.720	29.683	29.697	45	48	37	47	51	40	46.0	....	39	.273	.296	.181	.250
26	29.620	29.433	29.362	29.472	37	60	47	37.5	62	51.5	50.3	....	35	.214	.491	.264	.323
27	29.270	29.259	29.263	29.264	52	63	62	53.5	67	65	61.8	....	46	.368	.522	.516	.469
28	29.099	29.131	29.362	29.197	53	59	51	54	64	55	57.7	....	44	.389	.433	.321	.381
29	29.613	29.659	29.605	29.626	40	45	28.5	42	47	30	39.7	....	30	.221	.273	.199	.231
30	29.521	29.230	29.174	29.308	32	48.5	48	33	52	50	45.0	....	27	.168	.295	.309	.257
Means....	29.332	29.333	29.346	29.337	51.0	56.9	51.3	53.2	61.9	54.1	56.4	....	27	.362	.443	.32	.382
Oct. 1	29.066	28.983	29.094	29.046	48	56	48	52	58.5	50	53.5	....	47.0	.282	.416	.309	.336
2	29.164	29.308	29.361	29.278	48	48	35	50	50	37	45.7	....	37.0	.309	.309	.178	.265
3	29.406	29.393	29.389	29.396	41.5	45.5	28.5	43	48	30	40.4	....	29	.242	.272	.186	.233
4	29.371	29.000	29.256	29.209	28	54	45	29	56	46	43.7	....	25.5	.142	.391	.286	.273
5	29.415	29.436	29.679	29.510	44	40	41	45	42	43	43.3	....	40	.275	.291	.272	.279
6	29.773	29.741	29.732	29.749	40	48.5	43	40	52.5	45	45.8	....	34	.246	.288	....	.267
7	29.230	29.590	29.474	29.431	44	58	50	45	61	51	52.3	....	41	.275	.443	....	.359
8	29.349	29.115	29.050	29.171	6	62	55	63	71	57	63.7	....	48	.478	.436	....	.457
9	28.570	28.588	28.620	28.593	46	44.5	45.5	47.5	46	47	46.8	....	44.5	.291	.274	....	.282
10	28.753	29.017	29.069	28.946	45	46	45	46	47	47	46.7	....	44.5	.286	.297	....	.291
11	29.313	29.374	29.463	29.383	43	45	46.5	45	48	48	47.0	....	42.5	.251	.280	....	.265
12	29.520	29.499	29.497	29.505	42.5	46.5	33	45	50	34	43.0	....	33	.239	.271	....	.255
13	29.464	29.364	29.341	29.390	32	51	41	33	59	43	45.0	....	27.5	.168	.288	....	.228
14	29.297	29.265	29.268	29.277	46.5	51	41	49.5	56	43.5	49.7	....	41	.278	.305	....	.291
15	29.301	29.173	29.208	29.227	32.5	65	55	34	69	60	54.3	....	31.5	.165	.564	....	.364
16	29.259	29.301	29.318	29.293	49	50	47	52	55	51	52.7	....	47	.308	.329	....	.318
17	29.198	28.980	29.065	29.081	40	61.5	54.5	41	69.5	57.5	56.0	....	35	.235	.432	....	.333
18	29.044	29.028	29.169	29.080	47	58	50.5	51	64	53	56.0	....	50	.270	.401	....	.335
19	29.296	29.169	29.252	29.239	36	58.5	56.5	37	66	58	57.0	....	36	.199	.39	....	.294
20	29.075	29.022	29.143	29.080	60	69.5	59	66.5	74.5	61	67.3	....	36	.431	.65	....	.540
21	29.362	29.452	29.523	29.446	41	41	41	45	45	46.5	45.5	....	43	.305	.20	....	.252
22	29.645	29.635	29.675	29.652	41	40	30	47.5	44.5	31	41.0	....	30	.172	.1	....	.136
23	29.701	29.609	29.604	29.638	31	52.5	42.5	31.5	59.5	45	45.3	....	25.5	.168	.3	....	.234
24	29.643	29.612	29.630	29.628	37.5	50	33	41	54	35	43.3	....	34.5	.179	.3	....	.239
25	29.657	29.577	29.595	29.610	34	52	36	37	57.5	38	44.2	....	29	.157	.3	....	.229
26	29.673	29.610	29.606	29.630	35	50	33.5	37	53	35	41.7	....	30	.178	.3	....	.239
27	29.641	29.551	29.558	29.583	33	49	39	34	41.5	40.5	38.7	....	30	.175	.2	....	.238
28	29.643	29.635	29.655	29.644	38.5	51	48	40.5	53	50	47.8	....	40	.207	.3	....	.308
29	29.464	29.416	29.475	29.452	40	40	38	40	44	40	41.3	....	36	.248	.1	....	.299
30	29.413	29.362	29.429	29.401	40.5	41	37	42	42	38	40.7	....	35	.233	.2	....	.307
31	29.496	29.335	29.047	29.293	30	48.5	38	31	49	40	40.0	....	30	.155	.3	....	.235
Means....	29.361	29.327	29.363	29.350	41.1	50.7	43.2	43.2	54.4	45.2	47.6	....	04.0	.243	.329	.262	.277

the northern and northwestern lakes at Ontonagon, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation=1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
.869	.670	.850	.796	S.....	NE....	S.....	4	4	4	2.0	S. 28 E.	0	0	0	.....	.....
.853	.878	.781	.837	S.....	S.....	S.....	6.6	6	6.8	6.5	South..	3	6	8	.....	.....
.716	.816	.888	.807	W.....	W.....	S.....	9	13.2	2	7.7	S. 85 W.	7	2	0	.....	.16
.853	.907	.808	.856	S.....	S.....	S.....	6.2	4	3.5	4.6	South..	0	0	2	.....	.10
.774	.902	.888	.855	S.....	W.....	SW...	12.6	2.1	4.2	5.3	S. 20 W.	8	4	0	.....	.....
.847	.533	.916	.765	W.....	W.....	S.....	6	10	4	5.7	S. 76 W.	0	0	0	.....	.20
.767	.588	.853	.736	S.....	S.....	S.....	4	5	6	5.0	South..	0	2	3	.....	.....
.901	.9.7	.902	.903	SW...	S.....	W.NW	31	6	16.5	14.3	N. 60 W.	8	8	7	.....	1.02
.809	.643	.452	.635	W.....	W.....	W.....	12.6	9.9	10.5	11.0	West..	4	2	0	.....	.99
.851	.784	.798	.811	S.....	W.....	S.....	3	3	35	2.3	S. 25 W.	0	2	0	.....	.....
.836	.629	.868	.778	S.....	W.....	S.....	4	3.5	4	3.0	S. 23 W.	0	0	0	.....	.....
.902	.840	.864	.869	NE....	NE....	S.....	5	2	3	1.7	N. 68 E.	4	4	3	.....	.....
.861	.463	.850	.728	NE....	NE....	NE....	4	5	2	3.3	N. 45 E.	4	0	0	.....	.....
.864	.819	.840	.841	S.....	S.....	S.....	3	65	3	4.2	South..	0	4	0	.....	.....
.936	.913	.922	.917	S.....	S.....	S.....	3	3.5	6.5	4.3	South..	7	8	6	.....	.....
.834	.704	.840	.793	S.....	S.....	S.....	6.5	7	4	6.5	South..	6	6	6	.....	.60
.860	.935	.934	.910	S.....	W.....	S.....	4	4.8	2	2.7	S. 37 W.	8	7	0	.....	.....
.896	.665	.859	.807	NE....	S.....	S.....	4.8	2	2	1.3	S. 80 E.	0	0	0	.....	.30
.935	.....	.966	.956	S.....	SW...	W.....	5.6	4.5	7	18.0	S. 46 W.	0	7	0	.....	.....
.836	.772	.794	.801	W.....	W.....	S.....	7.2	9.5	2	5.7	S. 83 W.	0	0	0	.....	.22
.859	.778	.816	.818	S.....	S.....	S.....	4.2	4.8	2	3.7	South..	5	3	2	.....	.....
.847	.906	.857	.870	W.....	NE....	S.....	4.2	7	2	1.0	N. 13 E.	0	3	0	.....	.....
.864	.973	.731	.856	S.....	NE....	S.....	4	4.5	5.4	13.0	N. 54 E.	0	0	0	.....	.....
.703	.867	.906	.825	S.....	W.....	NW...	7.5	7.5	6.4	4.3	S. 78 W.	0	0	0	.....	.....
.847	.790	.732	.790	NE....	NE....	NE....	1.0	6.5	2	6.3	N. 45 E.	7	0	0	.....	.....
.952	.884	.689	.842	S.....	N.....	S.....	3	4.5	2.5	0.3	South..	0	0	0	.....	.....
.899	.790	.836	.842	S.....	N.....	S.....	4	2	4	2.0	South..	4	2	1	.....	.....
.933	.727	.743	.801	S.....	W.....	NE....	2.2	4.5	8	1.3	N. 22 E.	2	0	0	.....	.....
.829	.847	.836	.837	NE....	NE....	S.....	7.2	4	2	3.0	N. 54 E.	7	2	0	.....	.....
.893	.760	.856	.836	S.....	S.....	S.....	6.4	12	2	6.8	South..	0	2	0	.....	.....
.854	.782	.829	.824	.....	.....	.....	.....	.....	.....	2.1	S. 33 W.	2.8	2.5	1.3	.....	3.59
.727	.847	.856	.810	SE....	NE....	NE....	5.2	6.5	1.2	3.3	N. 79 E.	4	0	...	.....	.....
.856	.856	.807	.840	NE....	NW...	SE....	2	5.4	2	1.3	N. 16 W.	....	5	0	.....	.....
.874	.813	.836	.841	SW...	NW...	S.....	4	4.5	3.8	2.3	S. 58 W.	4	0	0	.....	.....
.887	.872	.921	.893	SE....	S.....	S.....	5	2	4.5	3.7	S. 18 E.	3	3	10	.....	.....
.920	.829	.833	.861	S.....	S.....	S.....	2	2	2	2.0	South..	4	4	0	.....	.....
000	.730	.840	.857	S.....	S.....	S.....	2	5.6	3.2	3.6	South..	5	3	2	.....	.....
920	.825	.929	.891	S.....	S.....	S.....	7	8.2	10	5.4	South..	4	2	5	.....	.....
831	.576	.874	.760	S.....	S.....	S.....	5.5	1.2	2	2.9	South..	0	2	...	.....	.....
.886	.882	.884	.884	NW...	NW...	NW...	9	9	9	3.7	N. 45 W.	8	8	9	.....	.96
.921	.923	.847	.897	NE....	N.....	NE....	9	8	7	5.3	N. 25 E.	9	9	9	.....	.92
.840	.777	.887	.835	NE....	NE....	NE....	5	4	5	3.0	N. 45 E.	7	9	2	.....	.25
.800	.750	.895	.815	NE....	NE....	E.....	3	2	3	2.3	N. 60 E.	0	0	0	.....	.....
.893	.537	.833	.754	E.....	.....	Calm..	3	....	0	1.0	East ...	0	....	1	.....	.....
.783	.687	.794	.755	NW...	NW...	Calm..	4	3	0	2.3	N. 45 W.	0	0	0	.....	.....
.843	.796	.708	.782	NW...	SE....	SE....	2	2	4	1.3	S. 45 E.	0	0	0	.....	.....
.794	.681	.722	.732	NW...	NW...	NW...	2	2	2	2.0	N. 45 W.	0	6	6	.....	.....
.912	.610	.814	.779	E.....	E.....	SW...	3	3	4	1.3	S. 52 E.	2	0	0	.....	.....
.722	.675	.830	.742	SE....	W.....	E.....	3	4	2	0.7	S. 11 E.	0	0	0	.....	.....
.903	.612	.906	.807	SE....	NE....	E.....	2	4	3	2.7	N. 80 E.	1	8	0	.....	.....
.663	.766	.882	.770	E.....	E.....	Calm..	3	6	0	3.0	East ...	0	8	9	.....	.....
.684	.684	.585	.651	NW...	W.....	W.....	7	7	3	6.0	N. 69 W.	6	4	3	.....	.20
.523	.641	.893	.686	W.....	W.....	SE....	6	6	2	3.7	S. 82 W.	2	1	0	.....	.....
.948	.595	.800	.781	E.....	W.....	E.....	3	3	4	1.3	East ...	1	0	0	.....	.....
.695	.738	.797	.743	E.....	W.....	W.....	3	4	2	1.0	West...	0	0	0	.....	.....
.712	.666	.811	.730	.....	NE....	E.....	....	3	2	1.7	N. 65 E.	....	0	0	.....	.....
.807	.798	.847	.817	E.....	NE....	E.....	2	2	3	2.3	N. 78 E.	0	0	0	.....	.....
.895	.869	.866	.877	E.....	E.....	E.....	2	3	3	2.7	East ...	0	0	0	.....	.....
.822	.864	.856	.847	S.....	NE....	Calm..	2	3	0	0.7	N. 81 E.	0	3	0	.....	A....
1.000	.677	.820	.832	NE....	NE....	NE....	3.5	1.0	5	3.0	N. 45 E.	4	2	....	.....	.....
.871	.914	.905	.897	SW...	S.....	.....	2	2	....	1.3	S. 21 W.	7	5	3	.....	.....
.893	.962	.820	.892	S.....	S.....	S.....	2	4	5	3.7	South..	0	3	4	.....	.....
.836	.757	.835	.809	.....	.....	.....	.....	.....	.....	0.4	S. 68 E.	1.4	2.8	2.3	.....	2.33

Reduction of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.				Dry bulb, or temperature of the open air.						Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°		°	°	°		°	°				
Nov. 1	28.792	28.797	28.902	28.831	51	50	49		51.5	52	50	51.2	....	40	.368	.334	.335	.346
2	29.124	29.129	29.174	29.142	38	44	39		41	46	40	42.3	....	28	.190	.362	.295	.226
3	28.998	28.922	28.997	28.972	41	32.5	30		42	34	31	35.7	....	30	.244	.162	.155	.187
4	29.304	29.322	29.324	29.317	31	34	32		31	34.5	32.5	32.7	....	28	.174	.189	.175	.179
5	29.443	29.503	29.527	29.491	31.5	38	28		32	38	28	32.7	....	22.5	.168	.229	.153	.183
6	29.539	29.439	29.214	29.404	20	33	36		20.5	34	36.5	30.3	....	18	.102	.175	.215	.161
7	28.889	28.746	28.795	28.810	34	54	57		35	57	58	50.0	....	34	.183	.378	.452	.338
8	28.461	28.556	29.580	28.866	40	54.5	38		42	56	38	45.3	....	35	.221	.385	.229	.278
9	28.483	28.652	28.874	28.670	40	41	31		41	42	33.5	38.8	....	32	.235	.244	.145	.208
10	29.077	29.125	29.180	29.127	31.5	30.5	31		33	33	32	32.7	....	29	.157	.141	.162	.153
11	29.086	29.508	29.617	29.437	29	31	27		29.5	32	31	30.8	....	28	.154	.162	.101	.139
12	29.667	29.420	29.429	29.505	24	38	40		24.5	40	41	35.2	....	24.5	.123	.203	.235	.187
13	29.373	29.108	29.146	29.209	22	45	38		22.5	49	39.5	37.0	....	27	.093	.247	.210	.183
14	29.358	29.438	29.524	29.440	34	35.5	29		36	37	31	34.7	....	28	.170	.188	.137	.165
15	29.400	29.421	29.181	29.334	27	38	37		28.5	44	39	37.2	....	26	.130	.151	.194	.158
16	29.595	29.447	29.351	29.464	26.5	29	32		30	32	35.5	32.5	....	26	.104	.136	.136	.125
17	29.389	29.497	29.544	29.477	32	29	23.5		31.5	32	24	29.8	....	24	.162	.126	.120	.136
18	29.539	29.505	29.550	29.528	22.5	41	16		23	42	16	27.0	....	15	.115	.244	.089	.150
19	29.505	29.387	29.230	29.374	16	26	26		16.5	28.5	26	23.7	....	16	.084	.112	.141	.112
20	29.248	29.360	29.322	29.310	27	35.5	30		28	36.5	31	31.8	....	24	.136	.195	.155	.162
21	29.131	29.014	29.045	29.063	31.5	35	30		32.5	37	30.5	33.3	....	27	.162	.178	.161	.167
22	29.121	29.101	29.148	29.123	33	44.5	38.5		34.5	50	42	42.2	....	30	.169	.221	.187	.192
23	29.140	29.063	29.059	29.087	30	49.5	39		31.5	55	41	42.5	....	30	.150	.276	.212	.213
24	29.105	29.258	29.399	29.251	41	34	31		42	35	32	36.3	....	30.5	.150	.281	.212	.214
25	29.437	29.428	29.422	29.429	30	31	28		31	32	29	30.7	....	28	.244	.183	.142	.190
26	29.472	29.433	29.479	29.461	28	35	25		28	39.5	26	31.2	....	24	.153	.145	.123	.140
27	29.316	29.295	29.366	29.326	31	32	29.5		32	33	30	31.7	....	25	.162	.168	.157	.156
28	29.418	29.364	29.331	29.371	29.5	26	21		30	26	21.5	25.8	....	21	.157	.141	.107	.135
29	29.320	29.315	29.293	29.309	9.5	6.0	4.5		10	6.5	5	7.2	....	2.0	.061	.151	.047	.086
30	29.344	29.426	29.302	29.387	4.5	6	3		5	6	3	4.7	....	-4.0	.047	.057	.050	.051
Means	29.239	29.232	29.377	29.240	29.4	35.3	30.7		30.5	37.3	31.8	33.2	....	-4.0	.159	.202	.172	.177
Dec. 1	29.145	29.130	29.080	29.115	15	18.5	14		15.5	20	15	16.8	....	.5	.080	.083	.071	.078
2	29.184	29.292	29.342	29.273	20.5	22.5	20		22	24	21.5	22.5	....	16	.093	.103	.091	.096
3	29.455	29.431	29.356	29.424	19	9.5	9		20	10	10	13.3	....	9	.092	.060	.054	.068
4	29.221	29.116	29.112	29.150	12	18	15		12.5	19	17.5	16.0	....	9.5	.069	.087	.057	.071
5	29.174	29.033	28.781	28.996	12.5	17	16		14	19	17.5	16.8	....	11	.059	.071	.073	.068
6	28.320	28.744	28.795	28.620	22	21.5	11		23.5	22.5	12.5	19.5	....	11	.101	.104	.054	.086
7	29.394	29.421	29.443	29.418	3	8	6		4	8.5	7	06.5	....	-2	.038	.057	.046	.047
8	29.555	29.585	29.568	29.569	4	13.5	11		4.5	14	12.5	10.3	....	-2	.046	.074	.061	.060
9	29.396	29.215	29.318	29.310	11.5	21.5	8.5		12	23	9	14.7	....	7	.067	.098	.058	.074
10	29.361	29.332	29.303	29.332	12	18	15		14	20	16.5	16.8	....	6	.052	.076	.089	.066
11	29.459	29.514	29.555	29.509	18	21	9		20.5	22	10	17.5	....	2.5	.070	.101	.054	.075
12	29.561	29.523	29.493	29.526	11	20	12		11.5	21.5	14	15.7	....	12	.066	.091	.058	.070
13	29.374	29.306	29.381	29.354	10	22	12		10.5	25.5	14	16.7	....	3.5	.062	.078	.052	.064
14	29.380	29.359	29.360	29.366	11.5	18	19		12	20	20.5	17.5	....	8	.067	.076	.086	.076
15	29.247	29.210	29.172	29.210	21.5	19	19		22	21	20.5	21.2	....	16	.109	.080	.088	.092
16	29.135	29.048	29.066	29.083	15	24	24		16	25	27	22.7	....	14	.074	.117	.095	.095
17	29.202	29.377	29.565	29.381	16	12	9		18	14.5	11	14.5	....	9	.067	.046	.043	.052
18	29.715	29.738	29.776	29.743	8.5	12	3		9	13	3	08.3	....	2	.058	.063	.050	.057
19	29.601	29.397	29.224	29.407	6	14	20		7	15	22	14.7	....	-5.5	.046	.071	.085	.067
20	29.274	29.502	29.550	29.409	18.5	15.5	15		20	16.5	16	17.5	....	14	.083	.076	.074	.078
21	29.499	29.267	29.023	29.263	8	14.5	14		9	16	15	13.3	....	0	.051	.067	.071	.063
22	28.817	28.993	29.331	29.047	29	14.5	19		30.5	15	20	21.8	....	17	.143	.078	.082	.101
23	29.415	29.371	29.101	29.296	9	15	13		10	16	14	13.3	....	7	.054	.074	.067	.065
24	29.119	29.114	29.306	29.180	24	24.5	25		25.5	26	26	25.8	....	12	.112	.115	.123	.117
25	28.575	28.655	28.809	28.680	31	33.5	29.5		32	34	30	32.0	....	20	.162	.185	.157	.168
26	29.283	29.135	28.896	29.105	7	13	18.5		7	14	20	13.7	....	5	.059	.087	.084	.076
27	28.812	29.054	29.164	29.010	25	19	14		25.5	19.5	14.5	19.8	....	12	.129	.097	.076	.101
28	29.407	29.371	29.406	29.395	10.5	12	13		11.5	13	14	12.8	....	7	.059	.063	.067	.063
29	29.761	29.735	29.735	29.744	9	10.5	12		10	11	12.5	11.2	....	5	.054	.064	.089	.069
30	29.870	29.782	29.640	29.764	9.5	20	1		10.5	22	1.5	11.3	....	0	.055	.085	.040	.060
31	29.436	29.234	29.016	29.229	10.5	24.5	17.5		11	27	19	19.0	....	-4	.064	.103	.079	.082
Means	29.295	29.290	29.279	29.288	14.3	17.7	14.3		15.2	19	15.6	16.6	....	-5.5	.075	.084	.072	.077

the northern and northwestern lakes at Ontonagon, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.965	.861	.927	.918	SW..	W....	W....	5.2	5	2	3.7	S. 71 W.	3	3	3	.....	.....
.738	.843	.910	.830	W....	W....	W....	8.5	5	2	5.2	West...	4	6	4	.....	.....
.914	.841	.893	.883	NE...	NW..	NE...	8	12.5	4	5.7	N. 1 W..	9	8	7	.....	.....
1.000	.948	.945	.964	NW..	NW..	W....	6	6	5	5.3	N. 57 W.	4	4	4	.....	.....
.948	1.000	1.000	.983	W....	NW..	W....	6	7.2	4	5.3	N. 71 W.	4	5	3	.....	.....
.926	.895	.950	.924	S.....	S.....	S.....	2	2	4	2.7	South..	10	10	0	.....	.....
.898	.812	.937	.882	S.....	S....	S.....	2	2	2	2.0	South.	4	2	0	.....	.....
.829	.842	1.000	.890	Calm..	SW..	SW..	0	5.4	4	3.0	S. 45 W.	10	0	0	.....	.....
.912	.914	.756	.861	SW..	W....	SW..	8.5	5	10.2	7.7	S. 55 W.	7	7	8	.....	.....
.848	.752	.896	.832	SW..	W....	NW..	5	8	6	5.0	N. 87 W.	7	9	10	.....	.06
.945	.896	.582	.808	NW..	N.....	NW..	8.4	5.5	4	5.7	N. 30 W.	6	7	8	.....	.....
.936	.820	.912	.889	S.....	S.....	N.....	2	3	5	.....	.....	4	0	0	.....	.....
.738	.710	.863	.770	S.....	SE....	NW..	4	2	3	1.3	S. 21 W.	0	4	0	.....	.....
.802	.854	.788	.815	NW..	W....	NE...	6.5	5.2	3	3.3	N 48 W.	4	5	7	.....	.....
.829	.522	.816	.722	S.....	W....	W....	4	8.8	12.2	7.3	S. 79 W.	6	9	10	.....	.....
.622	.694	.653	.656	N.....	SW..	W....	5.5	3	5	2.7	N. 65 W.	7	7	10	.....	.....
.841	.694	.934	.823	N.....	N.....	SE....	5	3	3	2.0	N. 20 E.	5	4	10	.....	.....
.932	.914	1.000	.949	SE....	NE...	S.....	2	2	2	1.0	S. 47 E.	10	0	0	.....	.....
.916	.716	1.000	.877	S.....	S.....	S.....	3	3	2	2.7	South..	7	0	0	.....	.....
.884	.902	.893	.893	S.....	NE...	S.....	2	3	2	1.0	S. 54 E.	0	6	0	.....	.....
.896	.807	.947	.883	S.....	Calm..	S.....	2	0	2	1.3	South..	2	0	0	.....	.....
.845	.614	.702	.720	S.....	Calm..	S.....	2	0	2	1.3	South..	7	0	0	.....	.....
.843	.650	.824	.772	S.....	S.....	S.....	2	3	3	2.7	South..	4	3	7	.....	.....
.843	.650	.824	.772	NE...	NE...	NE...	2	4	3	3.0	N. 45 E	10	8	10	.....	.60
.914	.898	.887	.900	NE...	NE...	E.....	4	3	2	2.7	N. 53 E	7	7	10	.....	.....
1.000	.595	.876	.824	S.....	SW...	S.....	2	2	2	2.0	S. 14 W.	0	0	0	.....	.....
.896	.893	.946	.912	S.....	W....	NW..	3	4	4	2.3	S. 83 W.	8	7	10	.....	.02
.946	1.000	.929	.958	SW..	NW..	N.....	2	3	5	2.3	N. 32 W.	0	0	0	.....	.....
.896	.882	.874	.884	N....	N.....	N.....	5.5	5.2	5	5.2	North..	10	10	10	.....	.06
.874	1.000	1.000	.958	N.....	S.....	S.....	4	3	2	0.0	South..	7	2	0	.....	.07
.882	.814	.882	.859	.....	.....	.....	....	....	....	1.4	N. 83 W.	5.5	4.4	4.4	.....	.82
.913	.776	.823	.837	S.....	S.....	S.....	12	12	12	12.0	South..	7	3	0	.....	.02
.790	.803	.787	.793	SW..	W....	W....	25	4.2	12	12.7	S. 63 W.	0	7	0	.....	.04
.850	.896	.791	.846	NW..	NW..	W....	12	5.2	35	16.3	N. 15 W.	7	5	0	.....	.02
.904	.845	.597	.782	W....	W....	W....	4.8	2.5	4.2	3.8	West..	7	6	7	.....	.03
.725	.692	.757	.725	N.....	S.....	W....	12	12	25	8.3	West..	7	3	0	.....	.04
.800	.862	.711	.791	SW..	NW..	NW..	12	8	10	7.3	N. 78 W.	8	6	0	.....	.10
.740	.890	.769	.800	W....	W....	W....	12.2	6.0	8.4	8.9	West..	0	7	0	.....	.14
.872	.908	.804	.861	SW..	NW..	SW..	6.2	35	4.8	4.0	S. 65 W.	0	0	0	.....	.08
.902	.797	.892	.864	S.....	SW..	SW..	4	12	4	6.3	S. 36 W.	7	4	0	.....	.....
.635	.702	.748	.695	N.....	S.....	S.....	12	4	2.5	1.8	North..	4	3	3	.....	.....
.635	.860	.791	.762	N.....	S.....	S.....	12	4	4	1.3	North..	4	4	10	.....	.....
.901	.787	.635	.774	S.....	S.....	S.....	4	4	2	3.3	South..	8	2	2	.....	.....
.898	.568	.635	.700	S.....	S.....	S.....	25	4	4	11.0	South..	2	0	0	.....	.....
.902	.702	.780	.795	S.....	S.....	S.....	2	4	4	3.3	South..	3	2	0	.....	.....
.930	.712	.780	.807	S.....	S.....	S.....	12	4	4	6.7	South..	8	7	0	.....	.....
.829	.872	.644	.782	S.....	E.....	S.....	2.1	4	4	2.7	S. 30 E	0	0	0	.....	.03
.682	.553	.596	.610	NE...	NE...	N.....	8.5	4	12	7.3	N. 24 E	0	0	0	.....	.14
.892	.810	1.000	.901	N.....	NE...	Calm..	4.5	4	0	2.7	N. 20 E	7	7	0	.....	.10
.769	.823	.721	.771	E.....	S.....	S.....	4	4	4	3.0	S. 27 E.	7	6	0	.....	.....
.776	.831	.829	.812	W....	W....	E.....	8.5	25	12	0.3	East...	8	7	4	.....	.14
.784	.743	.823	.783	S.....	S.....	N.....	2.2	4	4	0.7	South..	6	5	0	.....	.....
.839	.911	.850	.867	N.....	W....	W....	5.5	10.5	9.2	6.7	N. 74 W.	0	0	0	.....	.10
.791	.829	.816	.812	S.....	S.....	S.....	2.5	3.2	10.5	15.0	South..	10	6	10	.....	.....
.812	.815	.876	.834	SW..	N.....	S.....	8.7	4	4	3.0	S. 45 W.	6	7	10	.....	.07
.896	.947	.946	.930	S.....	S.....	SW..	12	4	8.5	7.7	S. 15 W.	7	8	10	.....	.....
1.000	.816	.776	.864	SW..	NE...	SE....	2	2	25	8.3	S 45 E	6	0	0	.....	.15
.938	.924	.910	.924	NE...	W....	W....	4.2	5.8	5.5	3.0	N. 71 W.	0	0	0	.....	.11
.800	.810	.816	.809	SW..	SW..	W....	4.5	25	10.5	12.3	S. 57 W.	6	4	2	.....	.13
.791	.899	.904	.865	W....	W....	W....	8.5	6.6	3.5	6.2	West...	7	8	7	.....	.05
.794	.721	.856	.790	N....	S.....	S.....	12	35	4	9.0	South..	4	5	10	.....	.10
.899	.703	.768	.790	S....	S.....	S.....	4.5	4	5.0	4.5	South..	0	0	0	.....	.....
.829	.800	.788	.806	.....	.....	.....	....	....	....	3.8	S. 43 W.	4.7	4.0	2.4	.....	.....

	5	29.107	29.059	29.058	29.075	26	26	12.5	26.5	27	13	22.2	37.5	11	.135	.136	.070	.11
	6	29.167	29.270	29.355	29.264	20.5	17.5	10	21.5	19.5	11.5	17.5	27.5	8	.099	.174	.051	.07
	7	29.357	29.248	29.128	29.244	11.5	18.5	18	12.5	20	19	17.2	24.5	8	.062	.083	.087	.07
	8	29.040	29.089	29.127	29.085	15.5	24.5	18.5	16.5	26	20.5	21.0	33.5	12	.076	.115	.078	.09
	9	29.116	28.934	28.982	29.011	13	13	10	14	14.5	11	13.2	18.5	9	.067	.061	.057	.06
	10	28.822	28.861	28.976	28.886	10	13.5	5	10.5	14.5	6	10.3	18	5	.062	.069	.043	.05
	11	29.067	29.302	29.383	29.217	5	14	12.5	5.5	13	13.5	11.3	18.5	3	.049	.071	.065	.06
	12	29.524	29.528	29.399	29.484	13	18.5	13	14	21	14.5	16.5	30	11	.067	.072	.061	.06
	13	29.138	29.113	29.202	29.151	14	19.5	17	15	21	18	18.0	21	11	.171	.088	.063	.06
	14	29.313	29.283	29.318	29.301	16.5	21.5	14	18	22.5	15	18.5	23.5	9	.075	.094	.071	.08
	15	29.306	29.291	29.151	29.246	12	19.5	21.5	13	20.5	22.5	18.7	23	9.5	.063	.094	.104	.08
	16	29.128	29.131	29.245	29.168	7	8.5	−9.5	8	9.5	−5	04.2	10	− 8	.048	.052	.018	.03
	17	29.446	29.599	29.692	29.579	1.5	17	15	2	18	16.5	12.2	21	−10	.041	.083	.071	.06
	18	29.642	29.623	29.561	29.609	14	17	6	15	18.5	6.5	13.3	21	5.5	.071	.077	.051	.06
	19	29.430	29.321	29.232	29.328	6	20.5	10	6.5	22.5	11	13.3	23	− 2	.051	.087	.057	.06
	20	29.035	29.006	29.007	29.016	11.5	18	14.5	13	20.5	15.5	16.3	25.5	7	.056	.070	.072	.06
	21	29.030	29.056	29.126	29.071	13	16.5	14	14	17	15	15.3	19.5	9	.067	.066	.071	.07
	22	29.206	29.293	29.392	29.297	11	15.5	10	11.5	16.5	10.5	12.8	18	8	.066	.076	.062	.06
	23	29.479	29.503	29.074	29.352	11	20.5	15.5	12	22	16.5	16.8	24.5	8.5	.061	.093	.076	.07
	24	29.651	29.723	29.582	29.652	12	23.5	20	12.5	24.5	20.5	19.2	25.5	8	.069	.114	.102	.09
	25	29.328	29.083	29.113	29.175	20	27	25	21	28	26	25 0	33.5	19.5	.096	.136	.123	.11
	26	28.959	29.038	29.074	29.024	14	13	12	15	13.5	13.5	14.0	17	10	.071	.072	.058	.06
	27	29.226	29.312	29.354	29.297	15	13.5	10.5	16	14	11.5	13.8	17.5	9.5	.074	.074	.059	.06
	28	29.329	29.240	29.332	29.300	8	8	0	9	9	1	06.3	13	− 1.5	.051	.051	.032	.04
	29	29.376	29.425	29.511	29.437	−9	3	−1	−9	3	−1	−02.3	10	−13	.028	.050	.041	.04
	30	29.399	29.171	29.078	29.216	−1	10	13	−1	11	14	08.0	18	−15	.041	.057	.067	.05
	31	29.006	28.812	28.743	28.854	16	27	25	17	28.5	26	23.8	31.5	0	.078	.130	.123	.11
Means...		29.247	29.228	29.230	29.235	11.3	17.2	12.9	12.1	8.4	14.0	14.8	38.5	−15	.067	.084	.070	.07
Feb.	1	29.085	29.150	29.183	29.139	20	21.5	16.5	26.5	22.5	17	20.0	30	13.5	.102	.104	.086	.09
	2	28.979	28.852	28.795	28.875	20	30.5	21	21	31.5	21.5	24.7	38	13.5	.096	.158	.107	.13
	3	28.703	28.742	28.851	28.765	24	29.5	28	25.5	32.5	29.5	29.2	33.5	16.5	.112	.129	.136	.12
	4	28.875	28.990	28.981	28.949	22.5	32	28	24	32	28.5	28.2	33	20	.103	.181	.148	.14
	5	29.039	29.102	29.149	29.097	26	32	20.5	26.5	35.5	21	27.7	40	19.5	.135	.136	.104	.12
	6	29.218	29.181	29.157	29.185	15	28.5	27	17	31.5	30	26.2	38	15	.063	.122	.113	.08
	7	29.134	29.052	29.043	29.076	26.5	38.5	32.5	28	41.5	34.5	34.7	43.5	20.5	.126	.194	.158	.15
	8	29.065	29.083	29.125	29.091	27	16.5	7	28	17.5	8	17.8	33.5	5	.136	.080	.048	.09
	9	29.148	29.296	29.446	29.297	−9	−1	−5	−9	0	−5	−4.7	10	−13	.028	.030	.034	.03
	10	29.682	29.734	29.646	29.687	−7	10	8	−6.5	12	9	04.8	20	−14	.028	.046	.051	.04
	11	29.386	29.430	29.530	29.449	9	20	7	10	22.5	8.5	13.7	33.5	5	.054	.079	.043	.05
	12	29.354	29.195	29.209	29.253	18.5	35	35	19.5	37	36	30.8	41	1.5	.089	.178	.191	.15
	13	29.243	29.242	29.536	29.340	28	27	20.5	29.5	27	21	25.8	32	20	.136	.147	.104	.12
	14	29.744	29.766	29.791	29.767	14	19	15	15	20.5	16.5	17.3	23	10.5	.071	.086	.089	.07
	15	29.671	29.432	29.082	29.395	4	26	27	5	28.5	28	20.5	36	4.5	.041	.112	.136	.08
	16	28.607	28.682	28.981	28.757	30	26	28	31	27.5	31.5	30.0	34	22	.155	.123	.113	.13
	17	29.348	29.401	29.361	29.370	21	24	21.5	22.5	24.5	23	23.3	30	19.5	.096	.123	.098	.10
	18	29.305	29.433	29.631	29.456	22	15	8	23.5	16.5	9	16.3	27.5	7	.101	.089	.051	.07
	19	29.652	29.549	29.496	29.566	6	16.5	6.5	7	18	7.5	10.8	22.5	2	.046	.075	.047	.05
	20	29.420	29.463	29.498	29.460	8	23	14	8.5	25	15	16.2	29.5	− 3	.057	.100	.071	.07

the northern and northwestern lakes at Marquette, Michigan.

VAPOR.				WIND.							Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
1.000	.886	.740	.875	N.....	NE....	E.....	4	4	4	3.0	N 45 E.	0	2	0	.....	.....
.867	.721	.874	.821	SE....	SE....	Calm..	12	4	0	5.3	S 45 E.	6	0	0	.....	.....
.898	.730	.800	.809	Calm..	SE....	W.....	0	4	2	1.0	S 15 E.	0	6	10	.....	.....
.888	.888	.887	.888	W.....	W.....	E.....	12	4	4	4.0	West..	6	8	10	.....	.10
.940	.883	.905	.909	Calm..	NW...	Calm..	0	12	0	4.0	N 45 W.	10	10	0	.....	.30
.857	.697	.701	.752	N.....	N.....	N.....	12	4	12	9.3	North .	5	8	0	.....	.05
.807	.776	.845	.809	W.....	SE....	SE....	4	2	4	1.3	S 3 E..	9	8	10	.....	.....
.831	.815	.707	.784	S	NW...	NW...	2	4	4	2.3	N 58 W.	9	8	10	.....	.05
.816	.730	.797	.781	NW...	NW...	NW...	12	12	25	16.3	N 45 W.	8	10	10	.....	.08
.898	.819	.760	.826	NW...	W.....	NW...	12	12	4	8.7	N 64 W.	8	4	0	.....	.....
.877	.823	.813	.838	NW...	W.....	NW...	12	4	4	6.3	N 54 W.	0	4	10	.....	.....
.816	.641	.730	.729	NW...	Calm..	SE....	4	0	25	7.0	S 45 E	9	6	10	.....	.....
.823	.783	.840	.815	NE....	E.....	Calm..	4	2	0	1.7	N 59 E	10	10	7	.....	.....
.761	.852	.823	.812	S.....	E.....	Calm..	2	2	0	1.0	S 45 E	10	8	4	.....	.09
.810	.852	.862	.841	S.....	SE....	SE....	2	12	25	13.0	S 43 E	1	4	8	.....	.....
.777	.787	.487	.684	W.....	W.....	W.....	2	12	12	8.7	West..	0	2	2	.....	.08
.859	.840	.752	.817	NW...	N.....	NW...	12	25	12	15.3	N 22 W.	6	9	10	.....	.08
.823	.765	.872	.823	NW...	NE....	NW ..	2	2	2	0.7	N 45 W.	9	8	0	.....	.....
.882	.725	.797	.801	NW...	Calm..	N	2	0	2	1.3	N 21 W.	2	8	3	.....	.....
.716	.635	.826	.726	NW...	NW...	NW...	4	2	4	3.3	N 45 W.	7	5	5	.....	.....
.816	.917	.823	.852	N.....	NW...	NW...	25	12	25	19.3	N 27 W.	5	10	8	.....	.11
.901	.831	.898	.877	W.....	W.....	W.....	12	4	2	6.0	West..	10	8	6	.....	.03
.804	.790	.831	.808	NW...	Calm..	Calm..	2	0	0	0.7	N 45 W.	8	6	8	.....	.....
.904	.870	.926	.900	N.....	Calm..	Calm..	2	0	0	0.7	North..	6	4	8	.....	.....
.855	.883	.876	.871	Calm..	E.....	NW...	0	4	25	7.3	N 38 W.	10	10	10	.....	.35
.823	.907	.721	.817	NW...	NW...	NW...	45	45	12	34.6	N 45 W.	10	4	0	.....	.38
.829	.908	.800	.846	NW...	N.....	W	12	25	4	12.0	N 20 W.	4	8	0	.....	.21
.784	.784	.707	.758	W.....	W.....	W	2	35	4	13.7	West..	5	4	0	.....	.....
1.000	1.000	1.000	1.000	N.....	NW...	Calm..	12	4	0	5.0	N 11 W.	0	0	0	.....	.....
1.000	.797	.816	.871	SE....	SE....	SE....	4	25	25	18.0	S 45 E	4	4	8	.....	.....
.834	.829	.876	.813	S	S.....	Calm..	4	25	0	9.7	South .	4	2	10	.....	.04
.851	.812	.810	.824	.....	.....	.....	....	....	....	3.5	N 46 W.	5.8	6.1	5.4	.....	1.95
.926	.862	.917	.902	NW...	W.....	E.....	4	4	4	1.3	N 45 W.	6	2	2	.....	.....
.855	.894	.929	.893	Calm..	E.....	Calm..	0	2	0	0.7	East...	6	6	0	.....	.....
.812	.700	.834	.782	NW...	NW...	E.....	2	2	4	1.0	N 23 E	10	10	10	.....	.....
.803	1.000	.943	.914	Calm..	E.....	Calm..	0	2	0	0.7	East...	8	8	6	.....	.....
.940	.653	.927	.840	W.....	W.....	W.....	2	4	2	2.7	West..	6	0	0	.....	.....
.671	.689	.675	.678	NW...	S.....	S.....	4	25	4	9.0	S 5 W.	2	0	0	.....	.....
.826	.741	.794	.787	S.....	SE....	SE....	35	25	4	19.7	S 20 E	4	2	0	.....	.....
.883	.837	.777	.832	NW...	NW...	NW...	25	12	12	16.3	N 45 W.	10	10	8	.....	.14
1.000	.695	1.000	.898	N.....	NW...	NW...	25	12	12	15.3	N 22 W.	2	0	0	.....	.....
.803	.610	.784	.732	Calm..	S.....	S.....	0	2	4	2.0	South .	0	0	10	.....	.....
.791	.658	.671	.707	SW...	NE ..	N.....	12	4	2	2.3	S 58 W.	9	0	0	.....	.....
.847	.807	.900	.851	SE....	S	Calm..	4	25	0	9.3	S 6 E..	8	4	4	.....	.13
.834	1.000	.927	.920	NW...	NW...	NW...	4	75	45	41.3	N 45 W.	10	10	4	.....	.41
.823	.780	.748	.784	NW...	N.....	Calm..	25	2	0	8.7	N 41 W.	8	6	2	.....	.....
.750	.716	.883	.783	Calm..	SE....	SE....	0	12	25	12.3	S 45 E	0	4	6	.....	.....
.893	.824	.639	.785	S.....	SW...	SW...	45	25	12	25.2	S 20 W	6	6	8	.....	.09
.794	.936	.797	.842	W.....	NE....	Calm..	4	2	0	1.0	N 62 W.	4	10	7	.....	.....
.800	.748	.784	.777	W.....	NW...	NW...	4	25	25	17.7	N 48 W.	8	8	6	.....	.06
.769	.761	.773	.768	N.....	E.....	Calm..	4	2	0	1.7	N 24 E	6	2	0	.....	.....
.890	.746	.823	.820	Calm..	E.....	NW...	0	4	12	3.3	N 27 W.	6	4	10	.....	.....
.904	.904	.730	.846	NW...	NW...	NW...	12	45	4	20.3	N 45 W.	10	2	4	.....	.16
.862	.648	.834	.781	NW...	SE....	SE....	4	45	25	22.0	S 45 E	4	4	10	.....	.08
1.000	.834	.244	.693	Calm..	NW...	NW...	0	25	2	9.0	N 45 W.	10	8	0	.....	.41
.847	.748	.877	.824	W.....	SE....	SE....	2	2	4	1.7	S 26 E	0	0	0	.....	.....
.784	.622	.702	.703	SE....	S.....	Calm..	4	25	0	9.3	S 5 E..	2	3	0	.....	.....
.886	.685	.783	.785	W.....	W.....	SE....	4	2	4	1.3	S 52 W.	0	4	0	.....	.....
.819	.699	.712	.713	Calm..	SE....	Calm..	0	35	0	11.7	S 45 E	1	0	0	.....	.....
.782	.761	.290	.811	W	W.....	W.....	4	12	2	6.0	West..	10	10	10	.....	.....
.843	.767	.796	.802	.....	.....	.....	....	....	....	2.4	S 84 W.	5.6	4.4	3.3	.....	1.48

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
March 1	28.761	28.570	28.723	28.685	34	38	22.5	35.5	39	23.5	32.7	49.5	22	.176	.216	.109	.167
2	29.236	29.395	29.400	29.344	–1	11	–5	–1.5	12	–5	01.8	19	8	...	.061	.034	.048
3	29.323	29.206	29.176	29.235	2	21	13	3	21.5	14	12.8	22.5	10	.036	.107	.067	.070
4	29.192	29.226	29.365	29.261	2.5	26	–0.5	3	28	–0.5	10.2	28.5	–0.5	.043	.117	017	.059
5	29.459	29.604	29.707	29.590	3.5	22	4	4	24	5	11.0	25	–5	.045	.095	.041	.060
6	29.668	29.514	29.456	29.546	7	20	21	8	21	22	17.0	28.5	–6.5	.048	.096	.101	.082
7	29.382	29.468	29.614	29.488	20.5	28	17	21.5	31	16.5	23.7	33	16.5	.098	.119	.077	.098
8	29.697	29.673	29.616	29.662	1	23	13	1.5	25	14	13.5	28	–3	.040	.100	.057	.069
9	29.516	29.416	29.354	29.429	17	28	27	17.5	30.5	29	25.7	32.5	10	.088	.125	.124	.112
10	28.981	28.732	29.063	28.932	29	34	27	31	36.5	29	32.2	38	26	.137	.163	.124	.141
11	29.446	29.541	29.530	29.506	8	21.5	7	9	25.5	8	14.2	28	6	.051	.069	.048	.056
12	29.478	29.446	29.368	29.431	12.5	23	10.5	13.5	25	11.5	16.7	25.5	5.5	.065	.100	.159	.075
13	29.245	29.278	29.344	29.289	–4	10	–1.5	–4	12	–2.5	04.5	19.5	–5	.036	.046	....	.041
14	29.410	29.368	29.421	29.400	–13	17.5	1.5	13.5	19.5	3.5	03.2	26	–21	....	.078	.035	.057
15	29.418	29.358	29.401	29.392	0	25	3	1	29	4	11.3	30.5	–4	.032	.089	.038	.053
16	29.404	29.283	29.201	29.296	6	25	17	7	28	18	17.7	31	–3.5	.046	.100	.083	.076
17	29.103	29.128	29.180	29.140	8.5	23.5	–2.5	10	27	2	11.7	28.5	–3.5	.046	.086	.035	.056
18	29.270	29.191	29.184	29.215	1	25	7.5	2	30.5	18.5	13.7	32	–10	.034	.072	.049	.052
19	29.342	29.498	29.584	29.475	8.5	30	14.5	9.5	34	16	19.8	41	2	.052	.128	.067	.082
20	29.637	29.588	29.676	29.634	9	35	26	10	40	27	25.7	44.5	5	.054	.139	.129	.107
21	29.483	29.351	29.341	29.392	16	35	31	17.5	38.5	32	29.3	41	13	.073	.158	.162	.131
22	29.347	29.388	29.421	29.385	29.5	35	31	31.5	38	32	33.8	43	28	.140	.165	.162	.156
23	29.365	29.285	29.348	29.333	31	38	28.5	32.5	41.5	30	34.7	44.5	27	.157	.190	.139	.162
24	29.490	29.454	29.472	29.472	18.5	23	16	20.5	25	18	21.2	25.5	15.5	.078	.109	.067	.085
25	29.586	29.661	29.686	29.644	12.5	25	11	13.5	28.5	12.5	18.2	30.5	7.5	.065	.085	.054	.071
26	29.642	29.513	29.429	29.528	10	24.5	24	11.5	26.5	26.5	21.5	28.5	4.5	.051	.109	.100	.087
27	29.371	29.363	29.376	29.370	24.5	30	23	26	35	24	28.3	37.5	18	.115	.109	.112	.112
28	29.395	29.408	29.379	29.394	25	31	23	26	35.5	24	28.5	40	19	.123	.122	.112	.119
29	29.303	29.238	29.204	29.248	30	36.5	32	31	42.5	34	35.8	45	20	.155	.138	.155	.149
30	29.173	29.105	29.092	29.123	37.5	46	46.5	38.5	56	46	46.8	60.5	34	.211	.179	.....	.195
31	29.093	29.005	28.850	28.949	35	38.5	30	40.5	47	34.5	40.7	53	29.5	.132	.122	.115	.123
Means ...	29.362	29.331	29.351	29.348	13.6	28.7	16.7	14.4	30.7	17.8	21.0	60.5	–8	.085	.116	.085	.095
April 1	28.749	28.792	28.900	28.814	28.5	39.5	34.5	35.5	42.5	39	39.0	51	28	.076	.203	.141	.140
2	29.235	29.373	29.261	29.290	29	36	26.5	34	43	29.5	35.5	45.5	25	.103	.121	.116	.113
3	29.312	29.268	29.317	29.299	30	38.5	33	34.5	45.5	37	39.0	47.5	28.5	.118	.142	.136	.132
4	29.255	29.258	29.262	29.258	32	30.5	28.5	34.5	32	30	32.2	37	28	.149	.153	.139	.147
5	29.231	29.188	29.158	29.192	26	39	31	27.5	42	33	34.2	44.5	24	.123	.199	.151	.158
6	28.949	28.865	28.912	28.909	33	38.5	33.5	34	46	38	39.3	53.5	28.5	.175	.143	.133	.150
7	29.096	29.201	29.254	29.184	30.5	38	26	34.5	42.5	38.5	35.2	47.5	27.5	.124	.177	.113	.138
8	29.335	29.471	29.534	29.447	28.5	36.5	25	30	43.5	26	33.2	43.5	19	.140	.125	.123	.129
9	29.492	29.351	29.241	29.361	33	46.5	30.5	36	61.5	35.5	44.3	62	21.5	.149	.119	.113	.127
10	29.240	29.357	29.384	29.327	32	27	22	34.5	29.5	22.5	28.8	37.5	20	.149	.118	.112	.126
11	29.255	29.118	29.118	29.164	32	61	37	36	67.5	44.5	49.3	69.5	15	.129	.459	.123	.234
12	29.096	29.080	29.068	29.081	38.5	43.5	31	48	55	34.5	45.8	58	....	.105	.258	.134	.166
13	29.063	29.047	29.145	29.085	45	54	43.5	52	70	54	58.7	74	52	.207	.206	.145	.186
14	29.156	29.033	28.955	29.048	43	53.5	47.5	47	65	51.5	54.5	67.5	45	.225	.257	.276	.253
15	28.978	29.023	29.033	29.011	42	42	41	44.5	44	45	44.5	49	40	.234	.241	.205	.227
16	29.205	29.166	29.269	29.217	38	49	39	41	57	46	48.0	....	32	.190	.262	.147	.193
17	29.322	29.451	29.544	29.439	40	34	31	50	39	36	41.7	....	31	.117	.131	.116	.121
18	29.531	29.513	29.158	29.401	34	47	39	41	48	47	45.3	53	38	.105	.310	.134	.183
19	29.285	29.168	29.075	29.176	45	38	51	53	45	52	50.0	73	39	.194	.138	.361	.231
20	28.863	29.006	29.200	29.023	46	43	32	46	44	35	41.7	56.5	33	.311	.264	.142	.239
21	29.216	29.200	29.184	29.200	29.5	31	28	32.5	35	31	32.8	36.5	28.5	.189	.198	.119	.125
22	29.173	29.249	29.304	29.239	28	31	25	29	32.5	26.5	29.3	37.0	24.5	.142	.157	.118	.139
23	29.424	29.473	29.453	29.450	33.5	35	29	36	41	32	36.3	45.5	29	.159	.196	.136	.137
24	29.390	29.306	29.331	29.342	38	39	33	41.5	44	34	39.8	55	21	.183	.173	.175	.177
25	29.270	29.135	29.092	29.162	39	42	35	42	47	38	42.3	58	21.5	.199	.208	.165	.189
26	28.729	29.065	29.248	29.014	40.5	30	27	43.5	32.5	28.5	34.8	43.5	26	.213	.138	.139	.164
27	29.321	29.303	29.238	29.287	28	36	29	30.5	41.5	32.5	34.8	45.5	19.5	.125	.140	.136	.130
28	29.155	29.072	29.045	29.091	35	47	38	43	62	48	51.0	63	29.5	.100	.125	.098	.108
29	28.911	28.827	29.098	28.945	39.5	47.5	42	45.5	51.5	44	47.0	52	40	.164	.276	.241	.227
30	29.307	29.283	29.231	29.274	29	35	28	31	39	29	33.0	42	.....	.137	.152	.142	.144
Means ...	29.185	29.188	29.200	29.191	34.9	40.3	33.2	38.9	46.3	36.9	40.7	74	15	.156	.187	.150	.164

the northern and northwestern lakes at Marquette, Michigan.

VAPOR.				WIND.								Amount of cloudiness, (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.849	.907	.866	.874	E.....	W....	NW..	4	25	25	15.0	N 72 W.	10	10	10	.....	.14
.....	.804	1.000	.902	NW..	NW..	NW.	25	12	2	13.0	N 45 W	8	2	0	.....	.....
.730	.929	.816	.825	S.....	S.....	S.....	2	12	2	5.3	South..	2	10	0	.....	.....
.864	.768	.500	.711	W....	W....	W....	2	12	2	5.3	West...	2	8	0	.....	.12
.869	.738	.750	.786	W....	W....	NW..	25	4	2	10.0	N 87 W.	0	1	0	.....	.....
.777	.855	.860	.831	E.....	SE....	SE...	25	45	12	25.7	S 58 E .	3	6	8	.....	.....
.857	.685	.765	.769	W....	NE ...	N.....	4	4	4	2.3	N 10 W.	2	3	4	.....	.....
.856	.746	.816	.806	W....	E.....	N.....	2	12	2	3.6	N 79 E	0	0	0	.....	.....
.919	.733	.775	.809	S.....	E.....	SE....	2	4	2	2.0	S 56 E.	8	4	10	.....	.....
.788	.756	.775	.773	E.....	NW..	W....	2	4	25	8.7	N 84 W.	10	10	2	.....	.36
.784	.507	.777	.689	W....	E.....	Calm..	12	2	0	3.3	West...	1	6	4	.....	.....
.813	.746	.800	.786	N.....	N.....	W....	4	4	2	3.0	N 13 W.	6	8	8	.....	.....
1.000	.610	.....	.805	NW..	SW ..	W....	25	25	2	12.5	West...	3	2	0	.....	.....
.....	.697	.724	.710	W....	N.....	W....	2	4	4	2.7	N 60 W.	0	0	0	.....	.....
.707	.556	.740	.668	SW ..	S	W....	25	2	2	9.3	S 45 W.	3	2	0	.....	.....
.769	.655	.840	.755	Calm..	E.....	N.....	0	2	2	1.0	N 45 E.	8	8	8	.....	.11
.687	.587	.842	.705	SW ..	SW ..	SW ..	12	4	2	6.0	S 45 W	0	0	0	.....	.....
.718	.422	.780	.640	Calm..	SE....	W....	0	25	4	7.3	S 38 E..	0	2	2	.....	.....
.787	.622	.743	.719	Calm..	SE....	W....	0	4	2	1.0	S 16 E..	0	0	0	.....	.....
.791	.557	.880	.743	Calm..	E.....	Calm..	0	2	0	0.7	East ...	0	0	0	.....	.....
.757	.677	.896	.777	W....	Calm..	Calm..	2	0	0	0.7	West...	4	6	8	.....	.....
.791	.719	.896	.802	Calm..	NE ...	Calm..	0	4	0	1.3	N 45 E	3	6	6	.....	.....
.848	.738	.836	.807	SW ..	S	NE ...	4	12	12	3.0	S 40 E	4	6	8	.....	.11
.707	.746	.682	.712	NW ..	NW ..	NW ..	4	4	4	4.0	N 45 W.	8	1	1	.....	.....
.813	.605	.711	.710	W....	E.....	W....	4	4	2	0.7	West...	0	0	0	.....	.....
.701	.757	.699	.719	Calm..	E.....	E.....	0	4	2	2.0	East ...	8	6	10	.....	.....
.815	.537	.868	.773	NW ..	N.....	NW ..	4	4	4	3.7	N 31 W.	3	0	0	.....	.....
.876	.588	.868	.777	SW ..	E.....	W....	4	12	2	2.7	S 71 E..	0	0	0	.....	.....
.893	.505	.792	.730	W....	E.....	N.....	12	12	12	4.0	North .	4	0	0	.....	.....
.906	.399	.....	.658	W....	S	W....	4	2	4	3.0	S 77 W.	2	0	0	.....	.....
.523	.379	.577	.493	Calm..	E.....	Calm.	0	2	0	0.7	East ...	1	2	0	.....	.....
.880	.662	.789	.750	.....	.....	.....	....	....	....	1.5	S 81 W	3.3	3.5	2.9	.....	.84
.366	.747	.590	.568	W....	N.....	NW ..	2	4	4	2.7	N 37 W.	0	0	0	.....	.....
.524	.433	.680	.546	NW ..	E.....	Calm..	4	12	0	3.3	N 74 E..	0	0	6	.....	.....
.582	.465	.619	.555	SW ..	E.....	Calm..	25	4	0	7.3	S 39 W	8	4	10	.....	.....
.744	.845	.836	.815	N.....	N.....	N.....	4	25	12	13.7	North ..	9	8	6	.....	.....
.824	.744	.800	.789	NW ..	NW ..	Calm..	12	12	0	8.0	N 45 W.	2	0	0	.....	.....
.895	.435	.581	.637	W....	W....	W....	25	25	12	20.7	West...	4	8	0	.....	.....
.622	.661	.716	.666	N.....	N.....	Calm..	2	4	0	2.0	N rth .	8	0	0	.....	.....
.836	.434	.876	.715	W....	N.....	Calm..	12	4	0	4.3	N 72 W.	8	0	0	.....	.....
.705	.217	.544	.489	W....	N.....	NW ..	35	4	2	12.3	N 81 W.	0	0	0	.....	.....
.744	.725	.931	.800	NW ..	NW ..	NW ..	35	12	2	16.3	N 45 W.	8	8	0	.....	.....
.610	.609	.416	.565	W....	.....	.....	12	....	....	4.0	West...	0	....	....	.....	.....
.318	.878	.669	.622	.....	.....	.....	....	....	....	....	....	....	....	....	.....	.....
.535	.281	.347	.388	.....	S	S	....	4	12	5.3	South	7	6	10	.....	.....
.698	.418	.724	.613	E.....	NE ...	S	2	2	2	1.3	S 80 E	....	10	0	.....	.....
.798	.836	.684	.773	N.....	N.....	Calm..	25	25	0	16.7	North .	0	2	0	.....	.....
.738	.521	.471	.577	Calm..	W....	W....	0	12	2	4.7	West...	0	0	0	.....	.....
.322	.547	.550	.473	W....	NW ..	W....	4	25	2	10.0	N 54 W	3	10	9	.....	.....
.407	.925	.413	.582	N.....	W....	SW ..	2	25	12	11.3	S 79 W	0	9	8	.....	.04
.483	.459	.930	.624	W....	SW ..	NW ..	2	4	12	5.0	N 68 W.	0	9	8	.....	.....
1.000	.918	.698	.872	SW ..	N.....	NW ..	35	25	2	8.7	N 87 W.	9	8	0	.....	.06
.698	.628	.685	.670	NW ..	NW ..	NW ..	2	2	2	2.0	N 42 W.	9	8	0	.....	.....
.867	.848	.818	.851	N.....	NW ..	Calm..	2	12	0	4.7	N 39 W.	0	0	0	.....	.....
.753	.488	.694	.642	Calm..	Calm..	Calm..	0	0	0	0.0	Calm...	5	4	0	.....	.....
.699	.597	.895	.730	S.....	S.....	Calm..	2	4	0	2.0	South .	5	0	0	.....	.04
.744	.624	.719	.696	S.....	S.....	Calm..	2	4	0	2.0	South ..	8	8	8	.....	.....
.753	.748	.829	.777	NW ..	NW ..	NW ..	2	25	2	9.7	N 45 W.	1	4	0	.....	.21
.733	.534	.694	.654	SW ..	N.....	SE....	12	4	4	3.0	S 39 W.	0	1	0	.....	.....
.357	.224	.292	.291	S.....	S.....	S.....	35	35	25	31.7	South	9	6	10	.....	.....
.538	.724	.836	.699	S.....	S.....	S.....	12	35	45	30.7	South .	6	0	0	.....	.22
.788	.636	.887	.770	NW ..	N.....	W....	25	12	4	12.3	N 36 W.	4	0	0	.....	.....
.657	.607	.681	.648	.....	.....	.....	....	....	....	3.9	N 88 W.	3.9	4.0	2.7	.....	.57

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.							Elasticity in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
May 1	29.310	29.348	29.414	29.357	26	32	25	29	33.5	26	29.5	54	25	.106	.162	.123	.130
2	29.516	29.521	29.492	29.530	25	34	22	26	36	27	29.7	38.5	20	.123	.170	.061	.118
3	29.457	29.368	29.236	29.354	32.5	36.5	34	34.5	47.5	36	39.3	52	30	.158	.203	.170	.177
4	28.931	28.878	28.945	28.918	39	44.5	39.5	41	46.5	41	42.8	50	39	.212	.267	.223	.234
5	28.958	29.008	29.144	29.037	41.5	45	36.5	46.5	51.5	40	46.0	52	34.5	.197	.214	.170	.194
6	29.193	29.244	29.289	29.242	31.5	34	31	35.5	37	34	35.5	39	30	.128	.157	.139	.141
7	29.296	29.318	29.321	29.312	34	37	27.5	36	40	29.5	35.2	41.5	27.5	.170	.181	.127	.159
8	29.251	29.198	29.158	29.202	35.5	39.5	33	38.5	44.5	36	39.7	49	23.5	.169	.177	.149	.165
9	29.133	29.123	29.141	29.134	36	41.5	33.5	38.5	48.5	37.5	41.5	50	32	.179	.170	.140	.163
10	29.232	29.246	29.263	29.247	38.5	42	37	43.3	52	43	46.2	54.5	35	.168	.136	.142	.149
11	29.335	29.403	29.510	29.416	41.5	43.5	31	49	52	35.5	45.5	54	35	.164	.171	.122	.152
12	29.460	29.423	29.346	29.430	42	44	38	50	53.5	44.5	49.3	56	28	.162	.170	.144	.159
13	29.164	29.108	29.078	29.117	38	40.5	39	43	46.5	43	44.2	49.5	38	.164	.174	.186	.175
14	29.031	28.980	29.018	29.010	40.5	42	34.5	46.5	49	38.5	44.7	53	32	.174	.175	.148	.166
15	29.062	29.156	29.188	29.135	37.5	39	32	39.5	45	35	39.8	48.5	34	.198	.160	.142	.167
16	29.191	29.218	29.241	29.217	41	42.5	30.5	46	49.5	35.5	43.7	52	25	.192	.184	.112	.161
17	29.358	29.424	29.503	29.428	40	44.5	35	46.5	51.5	38	45.3	55.5	36.5	.163	.201	.165	.176
18	29.568	29.538	29.503	29.536	42.5	46	35.5	47	56	39.5	47.5	57.5	38	.213	.179	.156	.183
19	29.407	29.356	29.318	29.360	43.5	42.5	39	52	49.5	45	48.8	55.5	31.5	.171	.181	.161	.171
20	29.307	29.291	29.258	29.285	39	46.5	40	43.5	54.5	44	47.3	56	39.5	.179	.211	.195	.195
21	29.213	29.158	29.118	29.163	38	41	39	41	47.5	43.5	44.0	50.5	39	.190	.172	.186	.183
22	29.094	29.115	29.105	29.105	38	39	36	42	45	43	43.3	49	38	.177	.160	.121	.153
23	29.114	29.105	29.075	29.098	38.5	42	35.5	45	52	41	46.0	55.5	30.5	.148	.136	.144	.143
24	28.990	28.972	28.941	28.968	44	50	44	51	54.5	46.5	50.7	58.5	34	.196	.301	.253	.251
25	28.819	28.843	29.055	28.906	44	43.5	37.5	47	45.5	40	44.2	50.5	35.5	.249	.256	.192	.232
26	29.217	29.281	29.341	29.280	39.5	42	38	46.5	50	43.5	46.7	53.5	34.5	.151	.162	.157	.157
27	29.392	29.416	29.296	29.368	40	43.5	39.5	46.5	51	44.5	47.3	56.5	30.5	.163	.184	.177	.175
28	29.353	29.284	29.206	29.281	37	40	41	42.5	44	43.5	43.3	48.5	36	.155	.195	.224	.191
29	29.173	29.205	29.256	29.211	42	51.5	47	43.5	53.5	50	49.0	57	38.5	.247	.355	.283	.295
30	29.422	29.463	29.459	29.448	42.5	45	41.5	47	51.5	45.5	48.0	64.5	41	.213	.214	.210	.212
31	29.405	29.401	29.356	29.387	38	49	48	43	58	55	52.0	69	34	.164	.259	.243	.222
Means....	29.215	29.246	29.254	29.248	38.3	42.1	36.1	42.8	48.2	40.1	43.7	69	20	.176	.194	.167	.179
June 1	29.307	29.198	29.043	29.183	42	48	49.5	52	52	51.5	51.8	68	44.5	.136	.282	.327	.248
2	28.690	28.674	28.713	28.692	48	53	46	50	57	48	51.7	59.5	42	.309	.350	.284	.314
3	28.846	28.967	29.052	28.955	53	58	54	57	68.5	58.5	61.3	72	44.5	.350	.343	.358	.350
4	29.249	29.340	29.316	29.302	49	48.5	41.5	53.5	55	45	11.2	64	43.5	.288	.253	.216	.253
5	29.229	29.112	29.022	29.121	51.5	64.5	65	64	85	75	74.7	88	42	.216	.333	.483	.344
6	28.965	29.022	29.132	29.040	64	66	50.5	69.5	74	52.5	65.3	82	50	.523	.532	.341	.465
7	29.199	29.248	29.326	29.258	49	54.5	48.5	51.5	58.5	51	53.7	58	45	.315	.372	.308	.332
8	29.392	29.420	29.398	29.403	53	58.5	58	56.5	66	62.5	61.7	76	45.5	.356	.391	.423	.390
9	29.408	29.359	29.385	29.384	64	65.5	61.5	75	84.5	68.5	76.0	85	58.5	.449	.374	.451	.425
10	29.321	29.171	29.205	29.232	59	69	64	71	85	70.5	75.5	87.5	55	.340	.594	.509	.481
11	29.163	29.084	29.110	29.119	63	72	61	67.5	86.5	66	73.3	88.5	64.5	.516	.589	.479	.525
12	29.257	29.328	29.401	29.329	62	61	50.5	70	64	55	63.0	74	41.5	.449	.497	.308	.418
13	29.369	29.315	29.148	29.284	52	55	59	51	61	67	60.7	72	47	....	.314	.393	.354
14	29.191	29.188	29.175	29.185	51.5	60.5	61	54	67	65	62.0	73.5	49	.348	.440	.483	.424
15	29.090	29.135	29.198	29.141	59.5	57.5	50	66.5	62	52	60.2	75	48	.416	.449	.334	.400
16	29.364	29.381	29.314	29.353	56	52	46	62.5	60	49.5	57.3	....	47	.363	.282	.265	.303
17	.....	29.002	29.188	29.095	....	65.5	54	....	75.5	59	67.3	78.5	47	....	.494	.351	.426
18	29.339	29.375	29.411	29.375	53	59.5	55	59	72.5	63	64.8	76.5	49.5	.323	.336	.337	.332
19	29.436	29.435	29.451	29.441	58	55	50	67	62	52	60.3	71.5	51	.363	.340	.334	.346
20	29.452	29.448	29.334	29.411	50	54	56	53	58.5	60	57.2	62	46	.321	.358	.396	.358
21	29.384	29.300	29.278	29.321	56	67.5	62	61.5	80.5	70	70.3	82.5	55	.389	.487	.449	.442
22	29.380	29.305	29.323	29.336	69	63	54	77	70.5	57	68.2	83	56	.601	.475	.378	.485
23	29.318	29.255	29.198	29.257	58	61	61.5	64.5	71.5	67.5	67.8	74	59	.396	.396	.466	.419
24	29.146	29.064	29.045	29.085	61	71	66	65	84.5	73	74.2	84	60.5	.483	.577	.545	.535
25	29.092	29.064	29.065	29.074	61	67	63.5	73	84	69.5	75.5	86	60.5	.376	.434	.504	.438
26	29.038	29.004	28.998	29.013	62	67	63	68	74.5	67	69.8	83.5	62.5	.476	.539	.522	.512
27	29.098	29.229	29.297	29.208	51	52	47.5	52.5	57.5	50	53.3	....	49	.354	.315	.296	.322
28	.....	29.388	29.334	29.361	....	61	52	....	75.5	56.5	66.0	72.5	42.5	....	.343	.329	.336
29	29.193	28.941	28.891	29.008	62	71.5	73.5	69.5	94.5	85	83.0	96.5	54.5	.456	.462	.670	.529
30	28.954	29.175	29.221	29.117	64.5	69	64	80	70	68	72.7	82	66	.399	.385	.543	.442
Means....	29.210	29.197	29.199	29.203	56.5	60.6	56.3	62.5	70.7	61.2	64.4	96.5	42	.362	.411	.402	.392

the northern and northwestern lakes at Marquette, Michigan.

VAPOR.				WIND.							Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles per hour.			Resultant velocity, in miles per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.665	.841	.876	.794	NW ..	N	NW ..	12	12	25	13.5	N.34 W.	8	2	8	.....	.....
.876	.802	.415	.698	NW ..	NE	E	12	4	4	4.0	N. 8 W.	6	0	0	.....	.....
.794	.914	.802	.833	SE....	SE....	Calm..	35	75	0	36.7	S. 45 E.	0	4	10	.....	.14
.824	.845	.867	.845	S	S	S	4	4	2	3.3	South ..	10	6	0	.....	.20
.620	.562	.688	.623	W	W	S	12	12	4	8.3	S. 80 W.	6	8	0	.....	.....
.628	.712	.712	.684	NW ..	NW ..	NW ..	4	4	4	4.0	N.45 W.	8	6	8	.....	.....
.802	.732	.778	.771	NW ..	NW ..	Calm..	25	4	0	12.3	N 45 W.	6	8	0	.....	.....
.722	.602	.705	.676	E	E	Calm..	12	4	0	5.3	East ...	0	4	2	.....	.....
.768	.498	.623	.630	E	NE ..	NW ..	2	4	4	2.0	N. 19 E.	6	3	0	.....	.....
.592	.350	.511	.484	N	N	N	25	12	4	13.7	North ..	0	0	0	.....	.....
.471	.441	.588	.500	NW ..	NE	Calm..	4	4	0	1.9	North ..	0	0	0	.....	.....
.450	.423	.490	.454	N	N	Calm..	12	2	0	4.7	North ..	0	7	7	.....	.....
.587	.548	.669	.601	Calm..	NW ..	Calm..	0	4	0	1.3	N.45 W.	7	8	6	.....	.....
.548	.505	.632	.562	NW ..	NE	Calm..	12	12	0	5.7	North ..	0	0	2	.....	.....
.818	.533	.698	.683	NW ..	NW ..	W	25	35	2	20.3	N.47 W.	6	0	0	.....	.....
.617	.510	.553	.557	Calm..	E	W	0	12	2	3.3	East ...	2	2	2	.....	.....
.513	.530	.719	.587	Calm..	NE	Calm..	0	4	0	1.3	N. 45 E	4	4	0	.....	.....
.660	.399	.640	.563	S	N	Calm..	2	4	0	0.7	North ..	0	2	0	.....	.....
.441	.510	.533	.495	E	N	Calm..	2	2	0	1.0	N. 45 E	4	6	6	.....	.....
.632	.497	.677	.602	E	NW ..	W	2	12	4	4.3	N.50 W.	8	4	6	.....	.....
.738	.523	.669	.643	NW ..	NW ..	NW ..	25	12	25	20.7	N.45 W.	8	6	8	.....	.....
.661	.533	.433	.542	NW ..	NW ..	NW ..	12	45	12	23.0	N.45 W.	8	6	0	.....	.....
.495	.330	.539	.461	N	N	Calm..	12	4	0	5.3	North ..	2	0	0	.....	.....
.525	.709	.807	.680	NE	NE	Calm..	2	2	0	1.2	N. 45 E	1	8	0	.....	.29
.772	.841	.776	.780	SW ..	NW ..	NW ..	4	12	35	15.7	N.50 W.	8	8	9	.....	.31
.477	.450	.555	.494	NW ..	SE....	Calm..	12	4	0	2.7	N. 45 W.	0	0	6	.....	.....
.513	.493	.602	.536	E	E	Calm..	2	25	0	9.0	East ...	10	4	0	.....	.....
.577	.677	.794	.683	W.....	E	NE ...	2	4	12	4.3	N. 50 E	6	10	10	.....	.37
.875	.865	.786	.842	NE	NE	Calm..	25	4	0	9.7	N. 45 E	10	3	0	.....	.50
.660	.562	.687	.636	NW ..	NE	Calm..	12	25	0	9.3	N. 17 E	4	0	0	.....	.....
.587	.475	.561	.541	NE ...	S	SE....	4	4	4	2.3	S. 53 E	0	4	4	.....	.....
.642	.588	.657	.629	.....	.....	.....	....	...	....	3.8	N.45 W.	4.3	3.9	3.0	.....	1.81
.350	.727	.860	.646	SE....	SE....	Calm..	4	4	0	2.6	S. 45 E.	4	8	10	.....	.15
.856	.752	.850	.819	E	NW ..	NW ..	4	4	12	4.7	N.33 W.	0	8	10	.....	.60
.752	.492	.729	.658	W	NE	Calm..	4	2	0	1.0	N.28 W.	5	1	0	.....	.04
.702	.590	.723	.672	NW ..	NE	Calm..	12	12	0	5.8	North ..	0	0	0	.....	.....
.362	.276	.558	.399	SW ..	SW ..	SE....	35	35	12	23.3	S. 35 W.	0	4	6	.....	.....
.725	.634	.862	.740	E	Calm..	Calm..	2	0	0	0.7	East ...	5	4	9	.....	.....
.826	.758	.824	.803	E	NW ..	Calm..	2	2	0	0.7	N. 17 E	9	7	7	.....	.60
.780	.612	.748	.713	E	SE....	Calm..	2	12	0	4.7	S. 51 E	3	0	0	.....	.12
.518	.316	.650	.495	S	SE....	W	12	25	2	11.0	S. 28 E	0	0	0	.....	.....
.449	.410	.683	.514	Calm..	SE....	S	0	45	2	15.3	S. 43 E	0	0	0	.....	.04
.766	.467	.735	.656	SW ..	SW ..	Calm..	12	25	0	12.3	S. 45 W.	3	3	2	.....	.....
.613	.833	.711	.719	NW ..	NE	Calm..	4	12	0	4.3	N. 26 E	1	0	0	.....	.....
.....	.527	.595	.561	Calm..	E	S	0	2	12	4.3	S. 9 E..	4	4	7	.....	.....
.834	.666	.783	.761	E	E	Calm..	4	4	0	2.7	East ...	2	3	5	.....	.07
.639	.753	.861	.751	NW ..	SE....	Calm..	2	4	0	0.7	S. 45 E.	4	2	2	.....	.....
.641	.546	.748	.645	NE ...	E	Calm..	2	4	0	2.0	N. 76 E.	0	0	3	.....	.....
.....	.560	.703	.632	.....	SW ..	W	....	45	4	15.7	S. 48 W.	....	4	3	.....	.08
.647	.421	.568	.545	W	W	W	4	12	2	6.0	West...	8	1	0	.....	.....
.530	.612	.861	.674	E	NE	Calm..	2	4	0	1.7	N. 61 E	0	7	10	.....	.....
.798	.729	.765	.764	NE ...	NE	NE	2	4	2	2.6	N. 45 E.	10	2	4	.....	.08
.739	.476	.613	.606	S	S	S	2	25	4	10.3	South ..	8	3	3	.....	.....
.648	.638	.812	.699	W	E	E	2	2	2	0.7	East ...	1	0	10	.....	.....
.653	.514	.692	.620	E	E	Calm..	2	2	0	1.3	East ...	1	1	2	.....	.....
.783	.487	.672	.647	SE....	SE....	SE....	2	25	2	9.7	S. 45 E	2	1	0	.....	.....
.464	.372	.702	.513	S	S	S	12	25	12	16.3	South ..	0	1	1	.....	.....
.695	.653	.790	.713	SW ..	SE....	S	4	4	4	3.2	South ..	2	2	3	.....	.07
.897	.666	.820	.794	NW ..	NW ..	Calm..	25	12	0	12.3	N.45 W.	4	7	0	.....	.....
.....	.389	.719	.554	.....	E	Calm..	....	4	0	1.3	East ...	.....	0	0	.....	.....
.632	.284	.557	.491	SW ..	SW ..	SW ..	25	23	12	20.7	S. 45 W.	3	0	0	.....	.....
.390	.525	.793	.569	W	N	Calm..	35	4	0	12.0	N.84 W.	1	1	0	.....	.....
.656	.566	.733	.646	.....	.....	.....	....	....	....	3.3	S. 21 W.	2.8	2.5	3.2	.....	1.85

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
July 1	29.216	29.215	29.186	29.206	59.5	60.5	55.5	68.5	72.5	60	67.0	79	54	.389	.367	.381	.379
2	29.178	29.091	29.165	29.145	68.5	70	59	76	91.5	63	76.8	93.5	57	.596	.456	.447	.500
3	29.151	29.095	29.100	29.115	64.5	61.5	59	70.5	70.5	62.5	67.8	77	56.5	.527	.426	.462	.472
4	29.177	29.188	29.182	29.182	54.5	61.5	52	56	66.5	54.5	59.0	67.5	50	.407	.479	.355	.414
5	29.093	29.080	29.081	29.085	55.5	60.5	54	58.5	64	57	59.8	67	45.5	.401	.479	.378	.419
6	29.118	29.128	29.061	29.102	53.5	58	53.5	56	63.5	56	58.5	63.5	47	.377	.418	.377	.391
7	29.239	29.248	29.344	29.277	53.5	60	52	61.5	76	57	64.8	78	50	.304	.305	.322	.310
8	29.367	29.393	29.408	29.389	51.5	56	51	58.5	66	55	59.8	68.5	44	.299	.316	.321	.309
9	29.359	29.338	29.308	29.302	56	59	57	68	71	65	68.0	71	53	.290	.340	.359	.330
10	29.056	28.922	28.787	28.922	57	68.5	61	69.5	72	74.5	72.0	79.5	56	.432	.650	.363	.482
11	29.042	29.281	29.384	29.269	62	55	50	68	59.5	52	59.8	72	51	.476	.373	.334	.394
12	29.467	29.479	29.442	29.463	50	52	47	53	57	50	53.3	67	42	.321	.322	.283	.309
13	29.455	29.530	29.378	29.454	56	60	54	62	75	59	65.3	77	41	.369	.318	.351	.346
14	29.354	29.270	29.150	29.258	60	74	56	66	80	72	72.7	80.5	50	.438	.758	.389	.522
15	29.206	29.288	29.361	29.285	59	62	56.5	63.5	71	63	65.8	77	56	.440	.436	.371	.416
16	29.436	29.455	29.431	29.441	56	59	53	63	70	60	64.3	78	51	.356	.354	.310	.340
17	.....	29.380	29.383	29.387	....	61.5	60	....	80	69	74.5	81	51	....	.298	.398	.348
18	29.404	29.405	29.376	29.428	59	63	58	65	71	64	66.7	73	54	.420	.469	.443	.431
19	29.346	29.314	29.380	29.347	59	72	61	65	85	67.5	72.5	86.5	58	.420	.609	.450	.493
20	29.458	29.408	29.345	29.404	64	66	66.5	71	75	73	73.0	83	57	.503	.519	.563	.528
21	29.345	29.301	29.225	29.290	65	69	62.5	72	77	66	71.7	80	64.5	.524	.601	.519	.548
22	29.216	29.207	29.173	29.199	64	72	68	67	82	70	73.0	83	58	.556	.650	.658	.621
23	29.175	29.169	29.172	29.172	64	78	70.5	79	89	78.5	82.2	93	65	.396	.809	.637	.614
24	29.230	29.230	29.213	29.224	70	66	60.5	77	73	64	71.3	80	63	.639	.545	.480	.555
25	29.201	29.213	29.208	29.207	59	65.5	62	63.5	75	64	67.5	75.5	57.5	.440	.501	.529	.490
26	29.209	29.128	29.070	29.136	60	68	66	64	77	73	71.3	81	49	.465	.564	.545	.525
27	29.000	28.956	28.982	28.979	67	73	69	74	86	74.5	78.2	92	67	.568	.636	.635	.613
28	28.932	29.032	29.264	29.076	64	64	50.5	69.5	71	54	64.8	82	53	.523	.503	.321	.449
29	29.372	29.428	29.428	29.409	56	62	58	60	72	63	65.0	74	57	.396	.422	.416	.478
30	29.382	29.345	29.286	29.338	62	64	58.5	70	76	61	69.0	83	57	.449	.436	.432	.439
31	29.000	29.007	28.995	29.001	60.5	64.5	61.5	63	70	65	66.0	72	58	.494	.533	.499	.509
Means....	29.239	29.243	29.230	29.241	59.7	64.1	58.2	65.9	73.7	63.4	67.8	93.5	41	.440	.480	.429	.451
Aug. 1	29.013	29.077	29.136	29.075	61	64	61.5	62	71	64	65.7	72	58	.523	.503	.503	.510
2	29.269	29.348	29.272	29.296	57	59	51	58	63	53	58.0	65	52	.452	.447	.348	.416
3	29.312	29.294	29.272	29.293	59	77	69	63	81	73	72.3	82.5	46	.447	.873	.655	.658
4	29.298	29.327	29.391	29.339	66.5	71	61	69.5	84.5	65	73.0	84.5	64	.606	.586	.483	.562
5	29.423	29.394	29.375	29.397	63.5	70.5	68	71	82.5	75	76.2	84	53	.485	.563	.591	.553
6	29.313	29.263	29.279	29.285	69.5	78	70	73	92	75.5	80.2	94	68	.673	.768	.659	.700
7	29.342	29.271	29.229	29.281	70	83.5	76	76	93.5	81.5	83.7	96	66.5	.652	1.010	.829	.830
8	29.214	29.140	29.126	29.160	73.5	79	75.5	79	96.5	85.5	87.0	97.5	73	.751	.753	.747	.750
9	29.291	29.338	29.396	29.342	61	61.5	57	62.5	75	61	66.2	75.5	58.5	.517	.339	.412	.423
10	29.468	29.508	29.511	29.496	58.5	69.5	61	64.5	76	64	68.2	79	53	.411	.633	.497	.514
11	29.466	29.382	29.275	29.374	59.5	66	65.5	68.5	81	72	73.8	84.5	59	.389	.438	.541	.456
12	29.020	29.070	29.156	29.082	62.5	69	58	65	72.5	60	65.8	75.5	56.5	.532	.661	.436	.550
13	29.202	29.201	29.181	29.193	54.5	59.5	59	56	67.5	66.5	63.3	71.5	46.5	.403	.401	.440	.401
14	29.246	29.348	29.417	29.337	62	62.5	55	66.5	68.5	58.5	64.5	70.5	56	.496	.485	.387	.456
15	29.464	29.468	29.413	29.488	54	65	58.5	56.5	71.5	62	63.3	73.5	48	.385	.530	.444	.453
16	29.333	29.162	29.080	29.192	61	76	65	70.5	85	72.5	76.0	87	55	.410	.775	.517	.567
17	29.000	28.999	28.974	28.991	69	72	65	76	94	71.5	80.5	94	61.5	.614	.488	.530	.544
18	29.104	29.199	29.262	29.188	54.5	53	53.5	56.5	55.5	56	56.0	56	51	.394	.383	.377	.385
19	29.317	29.378	29.357	29.351	51	61	47	54.5	68	51	57.8	71	47	.328	.443	.270	.347
20	29.357	29.340	29.301	29.333	54	65	59.5	58	77	64	66.3	77.5	53	.365	.457	.449	.424
21	29.275	29.227	29.205	29.236	64	71	68.5	69.5	80	72.5	74.0	82	59	.523	.637	.643	.601
22	29.125	29.080	28.960	29.055	67	67	69	71	71	72.5	71.5	84	64	.608	.608	.661	.626
23	29.037	29.090	29.225	29.117	62	64	59	68	81	64.5	71.2	84	62	.476	.369	.433	.426
24	29.346	29.383	29.334	29.354	52.5	60	53	58.5	69.5	58.5	62.2	71.5	49	.316	.391	.330	.346
25	29.331	29.309	29.252	29.331	59.5	68.5	63	67.5	87	73.5	76.0	89.5	53.5	.401	.448	.435	.428
26	29.303	29.224	29.172	29.233	60	69	65.5	66	91.5	73	76.8	92.5	55.5	.438	.406	.517	.454
27	29.075	28.947	28.992	29.005	65	71	58	70.5	76	66.5	71.0	79	64	.544	.691	.389	.535
28	29.083	29.138	29.222	29.148	53.5	57.5	51.5	60.5	71	55	62.2	76	53.5	.317	.294	.335	.315
29	29.310	29.369	29.412	29.364	47	51	44	50.5	60	48.5	56.3	59.5	45	.277	.253	.229	.254
30	29.347	29.277	29.148	29.257	43.5	57	52	48.5	67.5	61	59.0	73	41	.217	.333	.289	.273
31	29.136	29.261	29.338	29.245	55	50	45	57	55	50	54.0	56	47.5	.407	.295	.234	.312
Means....	29.252	29.252	29.247	29.250	59.7	66.1	60.1	64.3	76.3	65.0	68.5	97.5	41.	.463	.596	.469	.486

the northern and northwestern lakes at Marquette, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.560	.460	.736	.585	W	SE. ...	Calm..	4	4	0	1.0	S. 23 W.	3	0	0	.....	.....
.664	.304	.776	.581	W	S	Calm..	4	45	0	15.3	S. 5 W	2	4	9	.....	.....
.706	.573	.803	.694	Calm..	E	Calm .	0	12	0	4.0	East .	2	4	9	.....	.38
.9 3	.737	.836	.825	NW.	N ...	E	4	4	2	2.3	N. 7 W	10	2	2	.....	.....
.817	.8 6	.812	.812	Calm..	Calm..	Calm..	0	0	0	0.0	Calm ..	10	8	1	.....	.....
.840	.700	.840	.793	E	E.....	NW.	2	2	12	3.3	N. 27 W.	0	6	10	.....	.18
.557	.340	.692	.530	NW. .	NW . .	Calm..	12	25	0	12.3	N. 45 W.	0	1	0	.....	.....
.588	.495	.743	.609	SW . .	E	Calm..	4	4	0	1.0	S. 23 E	5	4	0	.....	.....
.424	.449	.582	.485	SE....	E	SE....	2	12	12	8.0	S. 66 E	1	1	3	.....	.....
.850	.828	.433	.704	S	S	S	4	12	4	6.7	South	2	5	4	.....	.33
.695	.734	.861	.763	W	NE ...	NW .	2	12	4	4.0	N. 18 E	8	7	0	.....	.32
.798	.692	.786	.759	N	SE....	Calm..	2	4	0	1.0	S 74 E	3	0	0	.....	.....
.665	.367	.703	.578	E	S	.....	2	4	0	1.7	S. 23 E	0	0	0	.....	.....
.685	.741	.665	.697	S	S	S	12	45	35	30.7	South ..	1	4	5	.....	.....
.751	.576	.644	.657	W	W	W	12	12	2	8.7	West ..	0	3	1	.....	.02
.619	.482	.599	.567	W	Calm..	Calm..	2	0	0	0.7	West...	1	1	0	.....	.....
.....	.292	.564	.428	Calm..	SW .	E	0	12	2	3.7	S. 39 W.	0	3	7	.....	.....
.680	.618	.675	.658	SE....	S	E	2	12	2	4.7	S. 14 E	7	7	8	.....	.....
.681	.507	.669	.619	SE....	SW . .	Calm..	2	4	0	1 7	S. 16 W.	7	2	7	.....	.....
.663	.599	.694	.652	SE....	NE ...	Calm..	2	2	0	0.9	East . .	0	2	1	.....	.....
.668	.648	.812	.709	Calm..	E	Calm .	0	2	0	0.7	East .	0	1	0	.....	.....
.841	.595	.898	.778	SE ...	SE....	Calm..	2	4	0	2.0	S. 45 E	3	2	0	.....	.....
.400	.592	.655	.549	W	E	W ...	4	2	4	2.0	West ..	3	4	0	.....	.....
.689	.672	.806	.722	W	E	Calm .	2	2	0	0.0	Calm ..	2	5	0	.....	.....
.751	.577	.888	.739	NW .	N	Calm..	2	4	0	2.0	N. 14 W.	1	0	0	.....	.....
.780	.608	.672	.687	Calm..	E	Calm..	0	2	0	0.7	East .	0	4	0	.....	.....
.677	.513	.744	.645	SW . .	NW . .	Calm..	25	4	0	8.3	S. 55 W.	6	3	7	.....	.25
.725	.663	.769	.719	W	W	W	4	25	12	13.7	West ..	0	8	10	.....	.39
.765	.539	.723	.676	E	N	Calm..	12	4	0	4.3	N. 72 E	0	1	9	.....	.....
.613	.486	.853	.651	NE ...	S	SE ..	2	4	25	9.3	S 43 E	0	7	10	.....	.04
.858	.727	.809	.798	W	S	SE....	4	2	2	1.3	S. 37 W.	10	9	2	.....	.30
.697	.578	.734	.663	.....	.....	.....	.....	.....	.....	2.1	S. 17 W.	2.8	3.5	3 4	.....	2.21
.942	.663	.859	.821	W	W	Calm.	4	12	0	5.3	West ..	9	3	1	.....	.....
.937	.776	.864	.859	W	NE ...	Calm .	4	4	0	1..	N. 23 W.	10	1	0	.....	.....
.776	.826	.807	.803	W	SW . .	Calm..	25	12	0	11.3	S. 76 W.	1	0	10	.....	.....
.846	.504	.783	.711	Calm..	Calm..	W	0	0	2	0.7	West ..	0	0	0	.....	.16
.640	.527	.681	.616	S	S	S	2	12	12	8.7	South ..	0	6	0	.....	.....
.830	.513	.747	.693	S	S	Calm..	12	12	0	8.0	South ..	5	5	0	.....	.....
.727	.642	.766	.712	Calm..	SW . .	SW .	0	12	4	5.3	S. 45 W.	0	2	1	.....	.....
.758	.437	.611	.602	S	S	S	12	12	4	9.3	South .	0	0	5	.....	.....
.913	.366	.769	.683	W	N	Calm..	2	4	0	1.7	N. 23 W.	10	0	0	.....	1.29
.677	.7 6	.853	.739	W	Calm..	Calm..	2	0	0	0.7	West ..	0	0	0	.....	.....
.560	.415	.686	.554	W	S	S	12	12	4	6.7	S. 37 W.	8	5	4	.....	.....
.863	.829	.880	.857	SW . .	NW . .	N	12	12	12	7.0	N. 54 W.	10	9	0	.....	.20
.903	.598	.615	.705	W	E	W	4	12	2	2.0	East .	0	0	4	.....	.....
.763	.697	.788	.749	NW .	NE ...	Calm .	2	4	0	1.7	N. 16 E	0	5	0	.....	.....
.842	.688	.800	.777	Calm..	E	Calm..	0	4	0	1.3	East ...	0	4	0	.....	.....
.550	.644	.648	.614	SW . .	S	SE .	12	25	12	14.0	South ..	3	4	4	.....	.....
.685	.3 6	.688	.560	SW . .	W	NW.	4	12	2	5.7	S. 85 W.	0	1	2	.....	.....
.873	.870	.840	.861	NW . .	NW.	N	4	12	12	8.7	N. 25 w.	1	10	10	.....	.11
.772	.647	.722	.714	W	E	Calm..	2	4	0	0.7	East ...	4	1	0	.....	.....
.756	.493	.753	.667	W	E	Calm..	2	2	0	...	.....	0	0	0	.....	.....
.725	.623	.805	.718	Calm..	E	E	0	4	4	2.7	East .	0	7	6	.....	.....
.8 2	.802	.829	.811	SE....	SW . .	E	2	2	12	4.3	S. 80 E	4	7	8	.....	.....
.695	.349	.727	.590	W	W	W	2	12	2	5.3	West...	1	0	0	.....	.....
.644	.543	.672	.620	W	W	N	4	4	2	3.0	N. 77 W.	0	0	0	.....	.....
.598	.349	.528	.492	S	S	Calm..	2	2	0	1.3	South ..	1	3	6	.....	.....
.685	.275	.648	.536	SW . .	S	SE ...	2	12	4	5.3	S. 4 E..	0	0	0	.....	.....
.729	.771	.568	.689	SW . .	NW . .	NW .	4	4	25	9.7	N 54 W.	1	8	0	.....	.....
.603	.388	.774	.588	W	W	W ...	12	45	2	19.7	West ..	10	3	1	.....	.....
.753	.493	.670	.639	W	W	W	4	25	2	10.3	West ..	7	2	0	.....	.31
.634	.503	.502	.546	W	SW . .	SW .	12	12	60	20.7	S. 51 W	4	4	1	.....	.....
.874	.681	.646	.734	N	N	N	12	12	4	9.3	North ..	10	9	0	.....	.....
.747	.578	.726	.684	.....	.....	.....	.....	.....	.....	3.3	S. 25 W.	3.2	3.2	2.	.....	2.07

Reductions of the monthly meteorological register of the survey of

Date.		Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
						Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
		7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.						°	°	°	°	°	°	°	°	°				
Sept.	1	29.412	29.366	29.296	29.358	46	51.	48	50	61	53.5	54.8	64	35.5	.258	.256	.263	.259
	2	29.207	29.063	29.072	29.114	15	57	52	51.5	62	54.5	56.3	68	45.5	.214	.399	.355	.323
	3	29.005	29.072	29.196	29.091	44.5	55	46.5	47.5	62.5	49	53.0	62.5	43.5	.254	.334	.284	.291
	4	29.237	29.173	29.055	29.155	48.5	63	56	53.5	77.5	62.5	64.5	28	45.5	.275	.382	.363	.340
	5	28.855	28.732	29.098	28.895	60.5	63	48.5	64.5	72	51.5	62.7	82.5	49.5	.474	.455	.303	.411
	6	29.220	29.311	29.446	29.326	45.5	55.5	44.5	49	67.5	47.5	48.0	69.5	41.5	.259	.282	.254	.265
	7	29.577	29.568	29.443	29.529	42	58	51.5	46.5	71	57	58.2	72	36.5	.208	.310	.308	.275
	8	29.409	29.256	29.098	29.254	56	58	61	58	61.5	63	60.8	63	53.5	.422	.436	.510	.456
	9	29.234	29.316	29.382	29.311	46	51.5	44	49.5	60	48	52.5	63.5	44.5	.265	.269	.236	.257
	10	29.445	29.353	29.261	29.353	44	51	50	46	69.5	56	57.2	70.5	42	.262	.130	.292	.228
	11	29.128	29.092	29.008	29.046	49	64	53	54	78.5	58.5	63.7	79	50	.282	.402	.330	.338
	12	29.105	29.168	29.144	29.139	55	54	53	59	59.5	55.5	58.0	62.5	53	.380	.345	.370	.365
	13	29.234	29.396	29.454	29.361	51.5	46	37	56.5	54	39	49.8	56.5	37	.315	.206	.194	.238
	14	29.533	29.498	29.461	29.497	38.5	53	50.5	40.5	63	54.5	52.7	64	30	.207	.277	.313	.265
	15	29.269	29.148	29.037	29.151	54	67.5	63	57	74.5	65	65.5	76	52.5	.378	.579	.549	.502
	16	29.112	29.124	29.169	29.135	69	76	73	70	83.5	77.5	77.0	86	64	.695	.796	.751	.747
	17	29.250	29.257	29.304	29.270	71	78	59	72.5	81.5	59	71.0	87.5	58	.738	.911	.500	.716
	18	29.493	29.550	29.551	29.531	55	51	49	51.5	63.5	49.5	54.8	65.5	48	.347	.209	.341	.299
	19	29.402	29.206	29.211	29.273	49	59.5	59	53	60	60	57.7	69	45	.295	.502	.497	.432
	20	29.326	29.431	29.518	29.428	52	51.5	50	53	66.5	53	57.5	69	49.5	.375	.181	.320	.296
	21	29.477	29.348	29.366	29.397	49	58	57	52.5	70	62	61.5	72.5	47	.253	.321	.399	.325
	22	29.408	29.543	29.591	29.514	58	57	50	64	61.5	53	59.5	66	52	.403	.406	.321	.377
	23	29.624	29.500	29.455	29.593	57	68	61	62.5	80	63.5	68.7	82	46	.392	.524	.503	.473
	24	29.308	29.124	29.278	29.237	60	68	54.5	64.5	84	61.5	70.0	87.5	44.5	.458	.470	.338	.422
	25	29.487	29.631	29.649	29.589	43.5	46.5	41	47.5	50.5	42	46.7	52	41	.231	.264	.244	.246
	26	29.565	29.406	29.308	29.426	40	58	50	41	69	52.5	54.2	70.5	33	.335	.316	.328	.326
	27	29.242	29.148	29.118	29.169	50	65	54	51.5	71	56.5	59.7	79.5	45	.341	.537	.385	.421
	28	29.043	29.084	29.246	29.124	60	69	53	61.5	80	54	65.2	87	52	.498	.561	.389	.483
	29	29.522	29.599	29.585	29.569	38	38.5	36.5	40	43	39	40.7	44.5	36	.203	.174	.183	.187
	30	29.551	29.327	29.212	29.363	31	51	46	32	61	51	48.0	62	27	.162	.242	.245	.216
Means....		29.323	29.286	29.300	29.303	50.3	58.1	51.7	53.3	67.3	54.9	58.5	87.5	27	.336	.383	.351	.357
Oct.	1	29.119	28.928	28.961	29.003	45	55	53.5	48	66.5	53.5	56.0	69	39	.260	.296	.410	.322
	2	29.052	29.214	29.330	29.199	48	47.5	37	48	52.5	39.5	46.7	57	37	.335	.261	.186	.260
	3	29.308	29.296	29.347	29.317	38.5	45	33	40.5	47	35	40.8	51	34	.207	.273	.162	.214
	4	29.356	29.258	29.266	29.293	30.5	48	39	33.5	56	43.5	44.3	57	28	.135	.230	.179	.181
	5	29.315	29.422	29.559	29.432	40	46	40	41	50	41	44.0	54.5	38	.235	.256	.235	.242
	6	29.688	29.678	29.725	29.697	42	51	36	43.5	56	37	45.5	59	35	.247	.309	.199	.251
	7	29.716	29.634	29.544	29.631	35	54	48	36.5	61	51	49.5	61	34	.184	.325	.296	.268
	8	29.432	29.233	29.253	29.306	49	59	51	51.5	71	53	58.5	71	48	.315	.340	.348	.334
	9	28.801	28.604	28.635	28.680	52	45	44	54	46.5	45	48.5	61	43	.362	.290	.275	.309
	10	28.630	28.868	28.993	28.830	45	47	45	45.5	47.5	45	46.0	56	43	.293	.316	.299	.303
	11	29.106	29.269	29.387	29.254	44	42.5	43	45	44.5	46	45.2	55	42	.275	.246	.238	.253
	12	29.435	29.468	29.484	29.462	42.5	49	39	44	53	40	45.7	55	39	.234	.295	.225	.251
	13	29.454	29.406	29.365	29.408	34	50	40	36	62	40	46.0	62	30	.170	.202	.248	.207
	14	29.267	29.234	29.240	29.247	45	57	48	48.5	65	51.5	55.0	68	38	.253	.359	.284	.299
	15	.....	29.293	29.256	29.275	...	58	50	....	61.5	52	56.8	70	38	....	.436	.334	.385
	16	29.189	29.273	29.287	29.250	55	58	44	56	63	46	55.0	66	44	.420	.416	.292	.376
	17	29.258	29.110	29.063	29.137	41	60	52	41	66.5	57	54.8	70	39	.237	.431	.322	.330
	18	29.068	29.032	29.125	29.075	50.5	68	57	55.5	80.5	69	68.3	81.5	53	.301	.517	.316	.378
	19	29.318	29.321	29.254	29.298	47	59	52	48	61.5	52.5	54.0	63	46	.310	.467	.322	.366
	20	29.144	29.125	29.185	29.151	60.5	73	63	62	82	65	69.7	82	51	.507	.690	.549	.582
	21	29.241	29.341	29.477	29.353	47	45	40	47.5	48	43	46.2	51	40	.316	.260	.276	.284
	22	29.501	29.557	29.657	29.572	35	42.5	34	36	47	36	39.7	49	34	.191	.213	.170	.191
	23	29.688	29.651	29.621	29.653	32.5	51	44	35.5	58.5	47	47.0	62	30	.145	.275	.249	.223
	24	29.610	29.601	29.592	29.601	39	53.5	42	43	61.5	43	49.2	66	41	.186	.304	.254	.248
	25	29.620	29.616	29.650	29.629	34	57	39	37	60	40	45.7	62	33	.157	.426	.225	.269
	26	29.655	29.641	29.621	29.639	32	54.5	39.5	34	60	41.5	45.2	64	31.5	.155	.352	.216	.241
	27	29.627	29.564	29.627	29.606	41	54	45.5	43	61.5	49	51.2	61.5	38	.231	.318	.259	.269
	28	29.623	29.589	29.559	29.588	34	54	39.5	36	59.5	41.5	45.7	60	33.5	.170	.345	.216	.244
	29	29.427	29.401	29.424	29.417	43	52	47	43	56.5	50	49.8	57	35	.278	.329	.283	.297
	30	29.367	29.326	29.357	29.350	44.5	47	37.5	47	49.5	39.5	45.3	52	38	.261	.290	.198	.250
	31	29.433	29.412	29.295	29.350	36	45.5	39	40	52	43.5	45.2	53	36	.160	.219	.179	.186
Means....		29.347	29.334	29.389	29.345	42.1	52.5	44.0	42.6	58.3	46.3	49.1	82	28	.252	.332	.265	.283

the northern and northwestern lakes at Marquette, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.716	.476	.640	.611	Calm..	E.....	SW...	0	12	12	3.0	S. 23 E.	0	0	0	.....	.....
.562	.718	.836	.705	S.....	S.....	W....	12	45	2	19.0	S. 2 W.	0	10	10	.....	.27
.774	.590	.817	.717	SW...	W....	NW..	12	12	2	7.7	S. 71 W.	9	3	0	.....	.....
.680	.406	.641	.576	W....	S.....	SE....	2	12	4	4.7	S. 3 E..	0	0	0	.....	.....
.781	.592	.792	.718	SW...	W....	Calm..	45	45	0	27.3	S. 68 W.	2	6	0	.....	.42
.745	.419	.774	.646	W....	W.....	W.....	4	4	4	4.0	West...	1	1	0	.....	.....
.657	.408	.663	.576	Calm..	SE....	SE....	0	25	12	12.3	S. 45 E	0	0	0	.....	.....
.876	.798	.886	.853	SE....	SE....	SE....	4	12	25	13.7	S. 45 E	8	10	10	.....	.51
.748	.519	.704	.657	NW..	NW..	NW..	4	12	4	6.7	N. 45 W.	1	0	0	.....	.....
.843	.180	.627	.550	W.....	W....	W.....	4	25	2	10.3	West...	2	1	0	.....	.....
.674	.413	.672	.586	SW...	SW...	Calm..	12	12	0	8.0	S. 45 W.	0	0	0	.....	.....
.761	.678	.839	.759	NW..	NE...	Calm..	2	2	0	0.9	North ..	4	3	0	.....	.....
.689	.493	.816	.666	N.....	N.....	N.....	4	12	2	6.0	North ..	2	0	0	.....	.....
.822	.470	.740	.677	SE....	SW...	SE....	4	25	12	10.0	S. 13 W.	5	6	6	.....	.....
.812	.679	.890	.794	SW...	S.....	SE....	12	25	4	12.7	S. 17 E	4	2	2	.....	.....
.948	.694	.797	.813	SW...	SW...	Calm..	4	25	0	9.7	S. 45 W.	4	4	0	.....	.....
.925	.848	1.000	.924	Calm..	SW...	Calm..	0	4	0	1.3	S. 45 W.	2	6	10	.....	.68
.635	.357	.963	.652	NW..	N.....	Calm..	2	4	0	2.0	N. 13 W.	6	0	0	.....	.06
.733	.969	.940	.881	SW...	SW...	N.....	12	4	25	6.0	N. 41 W.	6	6	10	.....	.36
.932	.281	.798	.670	W....	N.....	N.....	2	25	2	8.7	N. 9 W.	6	0	6	.....	.....
.743	.441	.718	.634	S.....	SW...	SW...	2	35	4	13.3	S. 43 W.	0	6	6	.....	.....
.675	.743	.798	.739	N.....	N.....	N.....	12	4	2	6.0	North ..	0	6	6	.....	.....
.694	.512	.859	.688	S.....	S.....	S.....	12	12	45	23.0	South ..	0	0	0	.....	.....
.755	.403	.609	.589	S.....	S.....	Calm..	45	60	0	35.0	South ..	2	0	0	.....	.....
.701	.719	.914	.778	N.....	N.....	Calm..	12	12	0	8.0	North ..	6	6	0	.....	.....
.912	.475	.829	.739	W....	W.....	E.....	12	4	4	4.0	West...	6	0	0	.....	.....
.895	.708	.842	.815	Calm..	SW...	Calm..	0	4	0	1.3	S. 45 W.	2	0	0	.....	.....
.912	.548	.933	.798	W.....	W.....	N.....	2	4	25	8.7	N. 14 W.	0	0	0	.....	.....
.820	.627	.770	.739	N.....	N.....	Calm..	12	4	0	5.3	North ..	8	8	4	.....	.....
.896	.452	.653	.667	S.....	S.....	S.....	2	25	45	24.0	South ..	0	2	0	.....	.....
.777	.553	.792	.707	.....	.....	.....	.....	.....	.....	4.9	S. 26 W.	2.9	2.9	2.3	.....	2.30
.777	.441	1.000	.706	SW..	SE....	S.....	45	25	4	18.3	S. 15 E	2	0	0	.....	.....
1.000	.663	.773	.812	W.....	W.....	W.....	12	12	4	9.3	West...	8	4	4	.....	.....
.822	.847	.797	.822	W.....	W.....	W.....	12	4	2	6.0	West...	4	6	4	.....	.09
.707	.512	.632	.617	W.....	E.....	Calm..	2	4	0	0.7	East....	0	2	10	.....	.04
.912	.716	.912	.847	W.....	E.....	NW..	2	2	4	1.3	N. 45 W.	8	4	0	.....	.....
.875	.687	.903	.822	W.....	E.....	Calm..	2	2	0	...	.....	3	0	0	.....	.....
.853	.606	.790	.750	Calm..	SE....	SE....	0	12	25	12.3	S. 45 E	2	2	4	.....	.....
.826	.449	.864	.713	SE....	SE....	S.....	12	45	4	2.0	S. 42 E.	2	0	0	.....	.....
.867	.883	.020	.890	S.....	SW...	W.....	25	25	2	15.7	S. 25 W.	10	8	6	.....	.37
.960	.962	1.000	.974	Calm..	W.....	NE...	0	4	25	7.3	N. 37 E.	10	8	8	.....	.45
.920	.838	.767	.842	NE...	NE...	N.....	12	12	25	15.3	N. 22 E	8	8	8	.....	.....
.798	.733	.910	.814	NW..	W.....	Calm..	4	12	0	5.0	N. 79 W.	4	0	0	.....	.....
.802	.364	1.000	.722	Calm..	E.....	Calm..	0	4	0	1.3	East....	0	0	0	.....	.....
.743	.582	.758	.694	NW..	W.....	Calm..	25	12	0	11.3	N. 60 W.	6	1	0	.....	.....
.....	.798	.861	.829	.....	SE....	SE.....	....	4	25	9.7	S. 45 E	....	0	0	.....	.....
.935	.723	.843	.834	N.....	E.....	Calm..	2	12	0	4.3	N. 81 E.	2	2	4	.....	.....
1.000	.663	.692	.785	Calm..	W.....	W.....	0	12	25	12.3	West...	1	0	0	.....	.06
.684	.497	.432	.538	SW...	S.....	SW...	25	12	4	12.7	S. 32 W.	0	0	0	.....	.....
.925	.855	.965	.915	W.....	E.....	Calm..	2	4	0	0.7	East....	0	2	0	.....	.....
.912	.632	.890	.811	SW...	SW...	SW...	25	35	12	24.0	S. 45 W.	4	1	8	.....	.....
.962	.777	.750	.830	W.....	NW..	NW..	12	12	4	8.7	N. 64 W.	8	6	6	.....	.36
.900	.660	.802	.787	NW..	NW..	NW..	4	25	2	10.3	N. 40 W.	2	2	0	.....	.....
.701	.561	.722	.678	NW..	NW..	SW...	12	12	4	6.7	S. 82 W.	1	0	0	.....	.....
.669	.557	.916	.714	W.....	SW...	W.....	12	4	2	5.7	S. 81 W.	0	0	0	.....	.....
.712	.822	.910	.815	W.....	E.....	W.....	2	4	2	1.3	East....	0	2	0	.....	.....
.792	.680	.826	.766	W.....	E.....	W.....	2	4	2	.....	.....	0	0	0	.....	.....
.833	.583	.745	.720	Calm..	S.....	Calm..	0	4	0	1.3	South ..	0	2	0	.....	.....
.802	.678	.836	.769	W.....	E.....	W.....	2	4	2	.....	.....	0	0	0	.....	.....
1.000	.719	.786	.835	E.....	NE...	NE...	2	12	4	6.0	N. 49 E	0	0	10	.....	.....
.809	.819	.818	.815	N.....	N.....	Calm..	2	4	0	2.0	North ..	10	6	0	.....	.....
.645	.566	.632	.614	NW..	NE...	W.....	2	4	25	8.3	N. 82 W.	2	3	0	.....	.....
.838	.673	.822	.780	.....	.....	.....	.....	.....	.....	2.3	S. 47 W.	3.2	2.2	2.3	.....	1.37

	6	29.554	29.474	29.353	29.469	23	37	32	25	43	34.5	34.2	46	22		.100	.155	.140
	7	28.939	28.865	28.833	28.879	39	48.5	45.5	42	66	50.5	52.8	63	31.5		.199	.110	.239
	8	28.520	28.532	28.650	28.567	47	56	40	50	62.5	47	53.2	63.5	44.5		.283	.369	.156
	9	28.547	28.610	28.758	28.655	34	42	38	41.5	50.5	44.5	45.5	56	36		.188	.176	.144
	10	28.991	29.011	29.072	29.025	33.5	35.5	29	36.5	43.5	34	38.7	51.5	30.5		.127	.104	.13
	11	29.225	29.346	29.505	29.359	29	31	29	32	35.5	32.5	33.3	41	29		.126	.194	.121
	12	29.583	29.576	29.318	29.492	24	32.5	29	26	36	32	31.3	40	24		.106	.15	.126
	13	29.317	29.178	29.073	29.189	35	42	35	38	48	39	41.7	54	29		.165	.189	.152
	14	29.167	29.312	29.415	29.298	30	32	28	35	36	30.5	33.8	40	28		.109	.15	.125
	15	29.414	29.048	29.069	29.177	22	32	25	24	36	37	32.3	41	21		.095	.129	.178
	16	29.490	29.476	29.325	29.430	25	27	30	26.5	30.5	31	29.3	36	24		.118	.107	.155
	17	29.251	29.388	29.451	29.363	32	27	22	33.5	29	24	28.8	34	22		.162	.124	.165
	18	29.427	29.431	29.488	29.449	22	29	18	23.5	33	20.5	25.7	37	18		.101	.114	.079
	19	29.440	29.342	29.203	29.395	18	26	28	19	28.5	30	25.8	35.5	15		.087	.112	.131
	20	29.144	29.294	29.345	29.261	33	37	29	35	39.5	31	35.2	41	28		.162	.188	.156
	21	29.167	29.018	29.018	29.068	35	46	40	37	52	43	44.0	53.5	32		.178	.232	.208
	22	29.028	29.089	29.111	29.073	42	48	38	45	53.5	40.5	46.3	54	33		.228	.268	.196
	23	29.146	29.120	29.083	29.116	30	48	45	31.5	52.5	48	43.7	55	38		.150	.276	.230
	24	29.076	29.136	29.305	29.172	47	38	32	50.5	39.5	33	41.0	52.5	31		.277	.240	.192
	25	29.303	29.271	29.302	29.292	30	32	30	31	33	31	31.7	40	28		.155	.108	.155
	26	29.325	29.412	29.4 7	29.391	28	32	23	29	34	25	29.3	38.5	22		.142	.155	.109
	27	29.297	29.221	29.257	29.258	28	32	30	29.5	33.5	32	31.3	37	22		.136	.168	.144
	28	29.305	29.301	29.265	29.290	24	26.5	25	26	28.5	26.5	27.0	30.5	24		.106	.129	.119
	29	29.172	29.165	29.178	29.175	17	10	5	18	11.5	5	11.8	26	-04		.183	.05	.055
	30	29.320	29.366	29.284	29.323	2	13	5	2	14	6	7.3	16	02		.147	.067	.093
Means.		29.182	29.177	29.197	29.185	30.0	35.0	30.4	32.6	39.5	33.1	35.1	63.5	-04		.146	.164	.144
Dec.	1	29.120	29.080	29.097	29.099	11	22	21	12	23.5	22	19.2	26	7		.061	.101	.103
	2	29.044	29.234	29.303	29.194	23	33	20	24	25	21.5	23.5	28	....		.112	.10	.091
	3	29.249	29.345	29.287	29.294	15	16	8	16	17	9	14.0	21	....		.074	.07	.051
	4	29.157	29.066	29.075	29.093	12	20	12	13.5	22	13	16.2	24	....		.058	.08	.061
	5	29.075	29.093	28.907	29.025	11	18	17	12	20	18.5	16.8	35	....		.061	.07	.077
	6	28.285	28.553	29.052	28.630	34	23	15	35	25	16	25.3	35	....		.183	.10	.071
	7	29.229	29.303	29.353	29.295	0	6	4	1	7.5	5	04.5	10	....		.032	.04	.041
	8	29.378	29.423	29.478	29.430	6	16	11	7.5	17.5	12	12.3	19	....		.040	.07	.046
	9	29.378	29.178	29.145	29.234	10	22.5	21	11	24	22	22.3	28	....		.057	.10	.087
	10	29.225	29.232	29.226	29.228	11	16	13	12.5	18	14	14.8	19.5	....		.054	.07	.067
	11	29.278	29.421	29.462	29.394	16	14.5	13	17	15.5	14.5	15.7	20	....		.078	.07	.061
	12	29.463	29.495	29.534	29.497	7	18	2	8	20	3	10.3	27.5	..		.048	.07	.066
	13	29.445	29.368	29.375	29.396	13	23	5	14	26	6.5	15.5	28	-10		.067	.09	.068
	14	29.365	29.360	29.362	29.362	11	27	18	12	30.5	20	20.8	31	5.5		.061	.10	.076
	15	29.261	29.162	29.167	29.197	18	25	22.5	20	26	24.5	23.5	27.5	11.5		.076	.12	.097
	16	29.149	29.100	28.999	29.083	15	26	27	16.5	27.5	26.5	24.2	29	13.5		.069	.13	.130
	17	28.957	29.224	29.435	29.205	27	24	16	28.5	26	17.5	24.0	32	15		.130	.10	.123
	18	29.590	29.682	29.726	29.666	9.5	14	9	10	16.5	10	12.2	17.5	7		.060	.05	.054
	19	29.615	29.474	29.268	29.452	10	20	24	11	33	25.5	19.5	32	9		.057	.09	.118

the northern and northwestern lakes at Marquette, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
.653	.422	.611	.562	SW..	SW..	Calm..	25	25	0	16.7	S. 45 W.	6	6	0	.....	.....
.478	.477	.595	.517	W	NW..	Calm..	25	4	0	9.3	N. 84 W.	6	4	10	.....	.....
.765	.807	.753	.775	E	NE...	NW..	12	25	35	14.3	N. 7 E..	10	10	4	.....	.75
.843	.900	.896	.880	NW..	NW..	NW..	25	35	25	28.3	N. 45 W.	0	0	0	.....	.12
.887	.610	.782	.760	W	W	W	4	12	2	6.0	West...	0	8	0	.....	.....
.746	.577	.744	.689	W	SE....	W	2	4	2	1.0	S. 23 W.	0	0	0	.....	.....
.744	.172	.649	.522	SE....	SE....	SE	4	4	12	6.7	S. 45 E	4	4	7	.....	.....
.786	.641	.483	.637	SE....	S	SW ..	12	25	12	14.0	Sou h..	0	0	0	.....	.....
.374	.424	.490	.429	SW..	W	SW ..	45	25	2	22.3	S. 60 W.	10	1	6	.....	.....
.542	.364	.524	.477	W	W	W	4	12	12	9.3	West...	2	6	7	.....	.....
.694	.588	.649	.644	NW..	NW..	NW..	12	4	12	9.3	N. 45 W	10	8	7	.....	.....
.754	.657	.6 4	.792	NW..	SW..	Calm..	12	4	0	4.3	N. 64 W.	1	10	4	.....	.....
.719	.563	.636	.639	N	E	W	12	12	12	4.0	North ..	9	1	0	.....	.....
.537	.610	.733	.627	NW..	NW..	Calm..	12	25	0	12.3	N. 45 W.	3	2	8	.....	.....
.738	.610	.807	.718	Calm..	SW..	W	0	12	25	11.3	S. 76 W.	5	8	8	.....	.....
.818	.628	.893	.780	N	W	N	12	4	4	5.7	N. 14 W.	10	4	10	.....	.....
.841	.775	.738	.785	N	N	N	4	25	4	11.0	North ..	6	8	8	.....	.09
.800	.606	.635	.680	NW..	W	Calm..	4	4	0	2.3	N. 66 W.	6	3	0	.....	.....
.845	.716	.782	.781	W	SW..	S	4	4	4	3.0	S. 45 W.	2	8	8	.....	.....
.797	.773	.798	.786	W	W	Calm..	2	2	0	1.3	West...	6	6	2	.....	.....
.807	.598	.750	.718	S	S	Calm..	12	25	0	12.3	South ..	6	0	0	.....	.....
.762	.640	.779	.727	W	E	W	2	4	2	..	.....	4	3	0	.....	.....
.843	.696	.777	.772	Calm..	SE....	S	0	4	4	2.3	S. 24 E	10	4	10	.....	.....
.753	.863	.893	.836	W	W	W	4	4	4	4.0	West...	6	6	10	.....	.....
.893	.893	.893	.893	W	NW..	E	4	4	4	1.3	N. 45 W.	10	8	10	.....	.....
.887	.792	.746	.808	W	W	Calm..	2	2	0	1.3	West...	6	4	0	.....	.10
.834	.841	.794	.823	E	W	W ...	2	4	4	2.0	West...	4	6	10	.....	.....
.754	.771	.818	.781	N	Calm..	N	2	0	4	2.0	North ..	8	10	10	.....	.....
.840	.701	1.000	.847	N	NW..	NW.	12	12	25	15.3	N 34 W	10	8	8	.....	.24
1.000	.816	.760	.825	NW..	NW..	SE...	4	4	4	1.3	N. 45 W.	4	2	0	.....	.26
.791	.651	.736	.714	.....	.....	.....	...	....	....	4.2	N. 77 W.	5.5	4.9	4.9	....	1.56
.804	.800	.860	.821	NW..	SW..	SW..	25	12	25	14.7	S. 79 W.	2	6	2	.....	.....
.868	.746	.787	.800	SW..	NW..	W	25	25	2	12.5	West...	1	8	4	.....	.....
.829	.834	.784	.816	SW..	NW..	W	12	25	2	10.9	N. 72 W.	6	6	4	.....	.15
.721	.721	.810	.751	SW..	SW..	Calm..	2	4	0	1.7	S. 74 W.	6	2	2	.....	.....
.804	.702	.765	.757	NW..	SE....	SE ...	25	12	25	4.0	S. 45 E	4	2	6	.....	.....
.898	.746	.829	.824	S	NW..	NW..	2	45	25	23.0	N. 46 W.	6	0	2	.....	.32
.707	.660	.750	.706	NW..	NW..	NW..	12	25	25	20.7	N. 45 W.	0	6	4	.....	.....
.660	.757	.804	.740	W	W	W	12	12	12	12.0	West...	0	6	4	.....	.....
.797	.803	.860	.820	Calm..	Calm..	SW..	0	0	25	8.3	S. 45 W.	6	6	4	.....	.....
.711	.682	.816	.736	W	W	W	12	4	2	6.0	West..	6	2	0	.....	.04
.834	.846	.730	.797	NE..	E	NE ...	4	4	12	6.3	N. 53 E	8	8	6	.....	.08
.777	.702	.730	.736	N	Calm..	SE...	4	0	2	1.0	N. 28 E	8	0	0	.....	.....
.816	.634	.647	.699	S	S	S	4	12	2	6.0	South ..	4	1	0	.....	.....
.804	.628	.7 2	.711	S	S	Calm..	2	2	0	1.3	South ..	6	1	10	.....	.....
.702	.876	.742	.773	N	S	Calm..	4	4	0	....	.....	10	6	10	.....	.....
.748	.824	.829	.800	W	E	E	4	4	4	1.3	East ...	1	6	10	.....	.20
.829	.754	.757	.780	Calm..	W	N	0	12	4	4.3	N. 72 W.	10	10	10	.....	.22
.896	.582	.791	.756	W	W	W ...	4	4	2	3.3	West..	5	5	0	.....	.....
.797	.721	.812	.777	S	S	S	2	2	12	5.3	South ..	10	10	10	.....	.....
.675	.680	.702	.686	W	W	W	25	4	4	11.0	West ..	8	8	5	.....	.28
.716	.738	.834	.763	S	W	E	2	2	12	3.7	S. 79 E	4	10	10	.....	.12
.775	.659	.761	.732	NW..	NW..	NW ..	2	4	12	6 0	N. 45 W.	10	10	10	.....	.43
.768	.669	.598	.678	NW..	SE....	SE....	4	2	25	7.7	S. 45 E	10	8	10	.....	.17
.716	.644	.684	.681	S	W	N ...	2	12	2	4.0	West ..	10	10	10	.....	.....
.659	.816	.675	.717	SE....	W	NW..	25	2	12	4.9	S. 37 W.	10	8	0	.....	.21
.784	.765	.746	.765	W	Calm..	E. ...	4	0	12	2.7	East ..	9	10	10	.....	.11
.768	.716	.765	.750	W	W	W	2	12	4	6.0	West...	9	7	10	.....	.....
.816	.823	.784	.808	W	W	W	4	4	25	11.0	West ..	10	4	0	.....	.....
.850	.663	.692	.715	NW..	NW..	NW ..	2	4	12	6.0	N. 45 W.	1	6	0	.....	.....
.780	.622	.716	.706	W	S	W	2	2	2	1.7	S. 66 W.	1	6	0	.....	.....
.629	.610	.783	.671	SW..	S	SW..	35	12	4	16.0	S. 35 W.	0	0	0	....	.....
.772	.724	.759	.752	....	.....	.....	....	....	...	4.2	N. 59 W	5.8	6.0	5.6	.....	2.33

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Jan. 1	29.768	29.741	29.708	29.739	- 3	6	5	- 2	9	7	04.7	11	- 3	.026	.023	.032	.027
2	29.525	29.325	29.350	29.400	3	16	11	4	21	14	13.0	23	4	.058	.033	.057	.036
3	29.3 0	29.2 3	29.214	29.239	15	25	27	17	30	31	26.0	33	12	.063	.078	.101	.081
4	29.282	29.247	29.140	29.223	25	29	30	29	33	34	32.0	36	25	.089	.114	.121	.108
5	28.967	29.080	29.266	29.104	30	26	23	31	30	25	28.7	42	25	.155	.095	.101	.117
6	29.281	29.384	29.453	29.373	21	22	18	24	26	21	23.7	29	16	.079	.072	.065	.072
7	29.466	29.331	29.194	29.330	11	23	23	12	27	26	21.7	29	12	.061	.078	.089	.076
8	29.085	29.190	29.214	29.163	22	21	22	24	25	25	24.7	31	21	.095	.067	.084	.082
9	29.150	29.029	29.027	29.069	16	21	15	18	25	18	20.3	31	17	.067	.067	.052	.062
10	28.970	28.955	29.037	28.987	11	10	10	13	13	12	12.7	19	12	.049	.034	.046	.043
11	29.198	29.330	29.520	29.349	8	12	6	10	15	8	11.0	18	8	.040	.041	.034	.038
12	29.620	29.500	29.239	29.453	4	21	24	6	24	25	18.3	27	5	.030	.078	.117	.075
13	29.082	29.131	29.281	29.164	25	23	20	27	26	23	25.3	34	23	.112	.089	.074	.092
14	29.382	29.254	29.266	29.284	16	26	25	18	29	27	24.7	33	18	.067	.100	.112	.093
15	29.426	29.364	29.306	29.365	15	25	19	17	28	21	22.0	31	15	.061	.10	.080	.081
16	29.299	29.284	29.445	29.343	9	8	- 8	11	11	- 7	05.0	23	-7	.043	.028	.018	.030
17	29.657	29.784	29.879	29.773	-16	- 3	- 5	-15	- 2	- 3	-06.7	1	-16	.009	.026	.012	.016
18	29.826	29.695	29.610	29.710	- 3	15	13	- 2	18	16	10.7	21	- 4	.029	.052	.044	.041
19	29.478	29.332	29.200	29.337	13	22	22	16	25	25	22.0	27	15	.044	.084	.084	.071
20	29.045	28.921	28.951	28.972	17	19	20	21	23	23	22.3	27	15	.049	.058	.074	.060
21	29.044	29 118	29.248	29.137	14	16	12	16	20	17	17.7	24	13	.059	.044	.018	.040
22	29.360	29.408	29.487	29.418	14	16	8	17	20	12	16.3	20	12	.048	.044	.017	.036
23	29.582	29.598	29.660	29.613	12	21	29	14	24	31	23.0	33	12	.052	.079	.137	.089
24	29.712	29.595	29.597	29.635	21	26	27	24	30	28	27.3	31	21	.079	.095	.136	.103
25	29.060	28.802	28.970	28.944	25	26	22	27	27	25	26.3	29	24	.112	.129	.084	.108
26	29.166	29.186	29.295	29.216	16	13	8	19	16	9	14.7	27	7	.056	.044	.051	.050
27	29.425	29.483	29.556	29.488	5	13	10	7	16	12	11.7	21	6	.032	.044	.046	.041
28	29.551	29.468	29.514	29.511	- 1	8	1	0	11	2	04.3	15	- 2	.030	.082	.034	.031
29	29.639	29.632	29.676	29.649	-10	3	- 5	-10	5	- 4	- 0.3	12	-11	.027	.027	.023	.026
30	29.626	29.481	29.306	29.471	- 1	13	19	0	16	20	12 0	22	- 5	.030	.044	.082	.055
31	29.193	28.945	28.992	29.043	14	34	34	16	37	37	30.0	42	16	.059	.157	.157	.124
Means....	29.359	29.316	29.342	29.339	10.6	17.9	15.6	13 2	21.2	18.1	17.5	42	-16	.058	.066	.070	.065
Feb. 1	29.302	29.254	29.216	29.257	21	28	19	24	29	20	24.3	39	20	.079	.142	.092	.104
2	28.982	28.763	28.783	28.843	28	28	26	31	30	29	30.0	32	16	.119	.13	.106	.118
3	28.8 2	28.833	28.899	28.845	13	30	18	14	33	20	22.3	35	13	.067	.132	.076	.092
4	28.854	28.828	28.997	28.893	28	30	30	29	31	30	30.0	33	17	.142	.155	.167	.155
5	29.282	29.326	29.346	29.311	22	28	18	24	32	20	25.3	34	21	.095	.108	.076	.093
6	29.498	29.474	29.419	29.464	11	24	24	13	29	28	23.3	32	13	.049	.072	.068	.063
7	29.386	29.288	29.293	29.322	28	42	34	32	45	40	39.0	47	27	.108	.228	.118	.151
8	29.206	29.218	29.279	29.234	31	21	10	36	24	13	24.3	42	13	.116	.079	.034	.076
9	29.369	29.335	29.524	29.409	- 4	0	- 5	- 3	2	- 4	-01.7	13	- 5	.025	.021	.025	.023
10	29.796	29.909	29.831	29.845	-11	6	7	-11	8	9	02.0	10	-11	.026	.034	.037	.032
11	29.562	29.490	29.549	29.534	18	32	32	21	37	36	31.3	40	9	.065	.116	.129	.103
12	29.488	29.383	29.308	29.423	34	37	37	38	41	40	39.7	43	37	.144	.168	.181	.164
13	29.122	29.082	29.484	29.229	36	42	30	37	43	34	38.0	45	34	.199	.254	.121	.191
14	29.675	29.700	29.703	29.693	24	25	26	27	28	29	28.0	35	36	.095	.100	.105	.100
15	29.574	29.282	28.952	29.269	27	30	35	29	32	37	32.7	38	29	.124	.144	.178	.145
16	28.937	28.995	29.212	29.048	26	30	26	29	35	31	31.7	40	27	.106	.109	.083	.099
17	29.472	29.434	29.338	29.415	18	33	31	24	39	34	32.3	41	23	.030	.110	.139	.093
18	29.152	29.324	29.462	29.313	31	33	29	33	37	32	34.0	42	25	.132	.136	.126	.131
19	29.549	29.352	29.280	29.394	22	26	26	25	29	28	27.3	33	25	.084	.146	.117	.102
20	29.319	29.330	29.373	29.341	26	29	25	29	32	27	29.3	34	26	.146	.126	.112	.145
21	29.238	29.387	29.526	29.384	25	29	20	27	34	23	28.0	35	23	.112	.103	.074	.096
22	29.582	29.479	29.202	29 421	20	21	26	22	28	29	26.3	35	18	.095	.033	.108	.078
23	28.877	28.752	28.980	28.870	31	32	24	32	36	27	31.7	41	27	.162	.129	.095	.129
24	29.325	29.410	29.477	29.404	8	14	12	11	18	15	14.7	29	10	.028	.037	.041	.035
25	29.465	29.410	29.452	29.442	7	28	25	8	32	27	22.3	33	8	.044	.108	.112	.089
26	29.660	29.684	29.662	29.669	17	30	29	19	35	30	28.0	38	19	.071	.109	.113	.098
27	29.692	29.588	29.488	29.589	22	37	32	24	44	35	34.3	45	24	.095	.120	.142	.122
28	29.388	29.293	29.208	29.296	34	38	33	37	43	36	38.7	46	34	.157	.164	.149	.157
Means....	29.341	29.307	29.333	29.327	17.6	28.0	24.2	23.2	31.6	27.0	27.4	47	-11	.096	.118	.105	.106

the northern and northwestern lakes at Milwaukee, Wisconsin.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.671	.356	.538	.522	NW...	W.NW	W.SW	0.7	0.6	0.2	1.0	N. 65 W.	0	0	0	.....	.....
.740	.293	.457	.497	Calm..	SW ...	Calm ..	0	2.9	0	1.0	S. 45 W	0	0	0	.....	.....
.671	.465	.582	.573	SW ..	SW ...	SW ...	0.5	1.0	0.4	0.6	S. 45 W.	10	10	0	.....	.....
.556	.606	.617	.593	Calm..	Calm ..	Calm ..	0	0	0	0.0	Calm ..	9	10	0	.....	.06
.893	.569	.746	.736	N.NE	N.NW.	NW ...	1.4	1.6	1.2	1.3	N. 11 W.	10	10	10	.....	.....
.610	.515	.570	.565	N.NW.	NW ..	Calm ..	1.2	1.5	0	1.0	N. 25 W.	10	1	0	.....	.....
.804	.529	.634	.656	Calm .	Calm ..	Calm ..	0	0	0	0.0	Calm ..	3	10	10	.....	.....
.738	.500	.622	.620	N.NW.	NW ...	Calm ..	1.1	1.0	0	1.0	N. 35 W.	10	0	10	.....	.02
.682	.500	.525	.569	Calm .	N.NE .	N.NE .	0	0.2	0.7	0.2	N. 43 E	3	9	10	.....	.....
.623	.438	.610	.557	N.NE .	NW ...	W.NW	0.2	0.2	0.4	0.2	N. 47 W.	10	10	10	.....	.....
.582	.475	.553	.537	Calm .	NW ..	Calm ..	0	0.4	0	0.1	N. 45 W.	10	0	0	.....	.....
.521	.610	.872	.667	Calm .	SE ...	SE	0	3.0	5.1	2.7	S. 45 E	10	10	10	.....	.05
.761	.634	.598	.664	W.NW	NW ...	NW ...	1.0	2.0	0.5	1.0	N. 49 W.	10	10	10	.....	.....
.682	.665	.761	.703	N	E.SE .	E.....	0.2	0.4	0.7	0.3	N. 81 E	10	10	10	.....	.18
.671	.655	.712	.679	Calm..	S.SW .	SW	0	1.4	0.2	1.0	S. 12 W	9	10	5	.....	.....
.596	.398	.594	.529	NW ..	NW...	N.NW .	1.5	4.0	3.5	2.7	N. 33 W.	0	0	0	.....	.....
.423	.671	.317	.470	N.NW.	NW ...	NW ...	2.4	3.1	1.2	2.0	N. 32 W.	0	0	5	.....	.....
.671	.525	.492	.563	Calm ..	Calm ..	Calm ..	0	0	0	0.0	Calm ...	1	10	10	.....	.....
.492	.622	.622	.579	Calm ..	Calm ..	E	0	0	1.5	5.0	East ..	10	10	10	.....	.....
.431	.467	.598	.499	E	E.NE .	NE	2.9	3.0	4.5	3.3	N. 61 E	10	9	9	.....	.....
.659	.412	.192	.421	N	N.NE..	Calm ..	1.1	1.0	0	0.7	N. 10 E	10	10	8	.....	.01
.5 9	.412	.229	.383	Calm..	NW	Calm ..	0	0.5	0	0.2	N. 45 W.	10	0	0	.....	.....
.635	.610	.788	.678	Calm..	NE	Calm ..	0	0.2	0	0.1	N. 45 E	3	0	5	.....	.....
.610	.569	.883	.687	Calm..	Calm .	SE	0	0	0.6	0.3	S. 45 E	10	10	10	.....	.....
.761	.880	.622	.754	E	E.NE.	N.NW.	5.0	2.4	4.0	2.3	N. 49 E	10	10	10	.....	1.75
.511	.492	.784	.606	N.NW.	NW ...	NW ...	3.0	3.5	0.2	2.0	N. 32 W.	8	0	0	.....	.....
.538	.492	.610	.547	NW ..	NW ...	W. NW	2.0	1.8	0.5	1.3	N. 49 W.	8	0	8	.....	.....
.695	.398	.718	.604	W.NW	W.NW	W. NW	0.9	1.4	0.5	1.0	N. 37 W.	5	0	0	.....	.....
1.000	.500	.645	.715	W.NW	W.NW	Calm ..	0.2	1.4	0	0.6	N. 75 W.	0	0	0	.....	.....
.695	.492	.800	.679	Calm..	S.SW .	S.SW .	0	0.7	0.8	0.6	S. 15 W.	8	10	10	.....	.09
.659	.712	.712	.694	Calm .	S.SW .	W. NW	0	0.2	2.4	1.0	N. 74 W.	9	10	0	.....	.....
.649	.531	.615	.598	.....	.....	.....	....	....	....	0.4	N. 5 E	7.0	5.8	5.5	.....	2.61
.610	.887	.850	.782	NW...	NW...	Calm ..	2.0	0.3	0	0.7	N. 45 W.	1	0	0	.....	.....
.685	.782	.665	.711	E.SE.	NE	N.NW .	0.7	3.3	0.5	1.3	N. 47 E	10	10	10	.....	.32
.816	.703	.702	.740	Calm..	Calm .	SW ...	0	0	0.2	0.2	S. 45 W	0	0	0	.....	.....
.887	.893	1.000	.927	SE	E.NE .	N	1.5	1.2	1.0	0.7	N. 79 E	10	10	10	.....	.21
.738	.594	.702	.678	Calm	W.NW	W.....	0	0.9	2.3	1.3	N. 79 W.	5	0	0	.....	.....
.623	.449	.543	.538	W.NW	SW ...	SW ..	1.8	1.0	2.0	1.3	S. 68 W.	0	0	0	.....	.....
.594	.762	.476	.611	SW	SW ...	SW ...	1.5	2.7	2.5	2.0	S. 45 W.	1	1	1	.....	.....
.550	.610	.438	.533	W.NW	NW...	NW...	1.0	3.2	3.0	2.3	N. 49 W.	10	10	10	.....	.....
.658	.438	.645	.580	.....	.....	.....	....	....	....	....	.....	5	0	0	.....	.....
1.000	.553	.508	.707	NW...	W.....	S SW .	0.2	1.0	2.0	0.7	S. 47 W	0	0	0	.....	.....
.570	.527	.610	.569	SW ...	SW ...	SW ...	3.5	1.8	1.3	2.2	N. 45 W.	10	0	10	.....	.....
.628	.653	.732	.671	SW ...	SW ...	SW ...	1.5	1.7	1.0	1.3	S. 45 W	10	10	10	.....	.69
.903	.916	.617	.845	S.SE ..	W.SW	NE ...	0.2	0.2	2.6	0.7	N. 45 E	10	10	10	.....	.14
.644	.655	.665	.655	NE	NE	NE	5.4	5.3	2.0	4.0	N. 45 E	10	10	10	.....	.....
.775	.794	.807	.792	E.SE..	SE	S.....	1.4	2.0	3.4	2.0	S. 26 E	10	10	10	.....	.36
.665	.537	.480	.561	W	W.....	W. NW	4.4	6.5	2.5	4.3	N. 87 W.	10	9	0	.....	.05
.235	.463	.712	.470	Calm ..	SW ...	Calm ..	0	0.5	0	0.2	S. 45 W	1	5	0	.....	.....
.703	.659	.694	.672	W.NW	NE	NE	0.5	1.8	2.0	1.0	N. 43 E	5	0	10	.....	.....
.622	.665	.768	.685	E.NE	E.NE..	E.NE..	2.5	1.6	2.1	2.0	N. 67 E	10	10	10	.....	.28
.665	.694	.761	.707	NE ..	NE	NE	2.6	3.0	2.0	2.6	N. 45 E	10	3	10	.....	.....
.761	.524	.598	.628	N.NE	NW ...	NW ...	1.2	1.6	0.5	0.7	N. 10 W.	10	7	10	.....	.02
.738	.215	.665	.539	E.NE	S.SW	S.SW	0.5	1.2	1.7	1.0	S 12 W	10	5	10	.....	.....
.896	.610	.644	.717	Calm ..	Calm ..	SW ...	0	0	1.0	0.3	S. 45 W	10	10	10	.....	.....
.398	.371	.475	.415	S.....	Calm ..	Calm ..	1.0	0	0	0.3	South ..	3	0	0	.....	.....
.777	.594	.761	.711	Calm.	SW ...	W. NW	0	0.8	0.2	0.3	S. 23 W	0	10	0	.....	.....
.692	.547	.675	.635	Calm.	S	W. SW	0	0.4	0.2	0.2	S. 19 W	1	1	0	.....	.....
.738	.446	.698	.627	Calm.	S.SW .	.....	0	1.0	....	0.3	S. 19 W	2	0	0	.....	.....
.712	.587	.705	.668	Calm	Calm ..	Calm ..	0	0	0	0.0	Calm ..	10	10	0	.....	.06
.688	.610	.666	.655	.....	.....	.....	....	....	....	0.2	N. 63 W.	6.2	5.0	5.0	.....	2.13

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
March 1	28.959	28.771	28.956	28.895	40	43	28	42	46	33	40.3	47	33	.221	.238	.096	.185
2	29.3 8	29.398	29.453	29.390	8	11	12	11	15	16	14 0	20	11	.028	.029	.029	.029
3	29.323	29.171	29.172	29.222	19	22	22	22	25	24	23.7	29	16	.069	.084	.095	.083
4	29.299	29.397	29.557	29.408	13	18	11	14	23	14	17.0	25	13	.067	.042	.067	.059
5	29.602	29.760	29.757	29.706	4.5	18	12	6	24	15	15.0	26	6	.036	.030	.041	.036
6	29.700	29.562	29.452	29.571	30	25	25	24	29	29	27.3	32	10	...	.089	.079	.089
7	29.470	29.592	29.674	29.579	21	30	21	23	32	24	26.3	34	22	.090	.144	.079	.104
8	29.772	29.712	29.642	29.709	13	25	22	15	29	25	23.0	32	15	.056	.089	.084	.076
9	29.582	29.456	29.299	29.446	22	30	31	25	34	32	30.3	37	14	.084	.121	.162	.122
10	28.932	28.859	29.213	29.001	33	36	28	35	40	33	36.0	42	23	.162	.160	.096	.139
11	29.542	29.525	29.403	29.490	19	23	25	24	28	29	27.0	35	23	.046	.066	.089	.067
12	29.385	29.405	29.415	29.402	24	24	24	27	29	27	27.7	31	26	.095	.072	.095	.087
13	29 48	29.548	29.608	29.545	0	2	0	2	4	2	02.7	27	0	.021	.025	.021	.022
14	29.693	29.676	29.682	29.687	- 6	9	7	-5	13	10	06.0	16	- 7	.021	.030	.026	.026
15	29.680	29.597	29.560	29.613	9	23	23	10	30	26	22.0	32	7	.054	.043	.089	.062
16	29.464	29.269	29.227	29.320	23	9	23	24	33	25	26.3	32	14	.112	.149	.160	.139
17	29.32	29.415	29.392	29.376	- 3	8	7	- 1	11	9	06.3	31	- 2	.015	.022	.037	.025
18	29.41	29.352	29.374	29.379	8	25	20	10	31	25	22.0	34	7	.040	.066	.050	.052
19	29.476	29.531	29.6 4	29.540	19	31	29	21	35	30	28.7	37	20	.08	.128	.149	.119
20	29.626	29.538	29.513	29.559	27	32	32	32	37	37	35.3	39	28	.09	.116	.116	.107
21	29.381	29.321	29.331	29.344	28	30	30	33	34	32	33.0	39	31	.086	.121	.144	.120
22	29.436	29.454	29.508	29.466	31	34	30	36	38	33	35.7	40	32	.116	.144	.132	.131
23	29.488	29.426	29.4 8	29.474	31	35	33	33	39	35	35.7	43	30	.151	.152	.162	.155
24	29.306	29.362	29.526	29.399	32	27	26	34	30	29	31.0	37	28	.155	.113	.106	.125
25	29.69	29.732	29.687	29.703	15	21	22	18	27	27	24.3	32	11	.052	.044	.061	.052
26	29.562	29 296	29.227	29.362	27	28	26	31	30	28	29.7	34	27	.101	.130	.117	.116
27	29.254	29.320	29.407	29.327	24	27	23	27	31	27	28.3	33	26	.095	.101	.078	.091
28	29.495	29.479	29.464	29.479	17	31	28	21	36	31	29.3	38	16	.049	.116	.119	.095
29	29.519	29.368	29.361	29.416	21	34	28	24	38	34	32.0	41	23	.079	.144	.085	.102
30	29.359	29.3 1	29.261	29.307	26	35	32	27	42	38	35.7	45	26	.122	.113	.103	.113
31	29 203	29.072	28.992	29.089	29	38	32	34	44	39	39 0	46	32	.103	.151	.080	.115
Means....	29.443	29.409	29.423	29.425	19.5	26.0	23.0	21.9	30.1	26.4	26.1	47	- 7	.084	.098	.090	.091
April 1	28.934	28.979	29.079	28.997	30	31	31	34	36	36	35.3	44	32	.121	.116	.116	.118
2	29.373	29.553	29.457	29.461	29	34	32	33	39	36	36.0	48	32	.114	.131	.129	.125
3	29.332	29.230	29.188	29.250	35	41	33	39	46	36	40.3	50	36	.152	.218	.149	.173
4	29.052	29.082	29.147	29.094	33	36	31	34	39	34	35.7	40	34	.175	.173	.139	.162
5	29.117	29.219	29.294	29.210	26	38	30	28	49	36	47.7	42	28	.17	.086	.088	.100
6	29.257	29.104	29.119	29.160	28	41	35	33	50	42	41.7	52	32	.096	.139	.113	.116
7	29.260	29.305	29.320	29.228	32	35	34	37	43	37	39.0	46	36	.116	.100	.157	.124
8	29.366	29.496	29.608	29.490	34	36	31	36	42	35	37.7	44	34	.170	.134	.128	.144
9	29.625	29.503	29.383	29.504	30	38	32	33	44	36	37.7	45	31	.130	.151	.129	.137
10	29.233	29.196	29.373	29.267	32	34	30	38	42	34	38.0	44	30	.103	.092	.121	.105
11	29.434	29.368	29.293	29.365	27	36	34	31	42	37	36.7	46	30	.101	.134	.157	.131
12	29.268	29.180	29.153	29.200	34	48	44	38	61	50	49.7	64	34	.144	.164	.208	.172
13	29.205	29.212	29.220	29.212	39	45	43	43	55	50	49.3	63	39	.188	.168	.186	.180
14	29.187	29.133	29.068	29.129	42	52	48	46	58	51	51.7	63	45	.215	.309	.296	.273
15	28.946	28.966	29.098	29.003	44	51	40	46	55	42	47.7	61	42	.262	.321	.221	.268
16	29.253	29.297	29.337	29.296	45	46	42	48	54	48	50.0	56	42	.260	.206	.189	.218
17	29.150	29.250	29.567	29.422	39	42	41	49	56	50	51.7	59	44	.108	.084	.139	.110
18	29.650	29.385	29.385	29.473	36	42	44	44	50	54	49.3	60	44	.108	.162	.157	.142
19	29.417	29.367	29.227	29.337	47	46	45	52	55	49	52.0	60	44	.257	.192	.247	.232
20	29.098	29.143	29.242	29.161	43	46	39	52	58	46	52.0	61	46	.164	.284	.147	.197
21	29.257	29.159	29.047	29.154	38	37	32	43	40	34	39.0	47	34	.164	.181	.155	.167
22	29.090	29.243	29.376	29.236	29	31	28	31	36	31	32.7	47	30	.137	.116	.119	.124
23	29.478	29.513	29.498	29.496	30	34	31	33	38	36	35.7	41	31	.132	.144	.116	.131
24	29.466	29.418	29.460	29.525	32	41	38	35	49	43	42.3	52	34	.142	.153	.164	.153
25	29.463	29.368	29.317	29.383	37	45	41	43	53	47	47.7	58	38	.142	.194	.179	.172
26	29.051	29.038	29.235	29.108	43	43	32	51	57	40	49.3	61	40	.173	.095	.077	.115
27	29.503	29.475	29.435	29.471	27	33	31	31	39	38	36.0	42	29	.101	.110	.092	.101
28	29.378	29.255	29.170	29.268	35	41	38	41	49	43	44.3	50	33	.126	.153	.164	.148
29	29.061	29.958	29.073	29.031	43	53	46	49	60	53	54.0	65	43	.199	.310	.219	.243
30	29.280	29.323	29.315	29.306	37	37	33	42	43	36	40.3	54	36	.155	.116	.149	.140
Means....	29.273	29.268	29.283	29.275	35.2	40.4	36.3	39.8	47.9	41.3	43.0	65	29	.152	.164	.152	.156

he northern and northwestern lakes at Milwaukee, Wisconsin.

VAPOR.				WIND.							Amount of cloudiness. (0 = clear sky. (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.				
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.829	.767	.510	.702	S. SW	W.NW	NW ..	0.5	1.9	2.7	1.3	N. 57 W.	10	10	9	.....	.....
.328	.304	.327	.320	N. NW.	N. NE.	Calm..	2.5	1.0	0	1.0	N. 9 W	10	9	10	.....	.....
.584	.622	.738	.648	SE	E. SE.	Calm..	0.5	0.7	0	0.3	S. 63 E	10	10	10	.....	.13
.816	.337	.457	.533	NW	NW ..	Calm..	0.2	1.9	0	0.7	N. 45 W	0	0	0	.....	.....
.640	.235	.475	.450	W.NW	NW .	Calm..	0.6	0.5	0	0.3	N. 57 W.	0	0	0	.....	.....
.....	.556	.556	.556	SE....	E. NE	E. NE	1.3	1.0	0.7	0.7	N. 79 E	10	10	10	.....	.....
.730	.794	.610	.711	N.NW.	W.NW	Calm .	0.4	1.0	0	0.3	N. 73 W.	10	10	0	.....	.....
.648	.556	.622	.609	Calm..	Calm..	Calm..	0	0	0	0.0	Calm....	10	9	5	.....	.....
.622	.617	.896	.712	Calm..	SE	SE	0	0.8	1.3	0.7	S. 45 E	10	9	10	.....	.....
.797	.645	.510	.650	S. SE.	W.NW	NW	0.5	2.8	2.2	1.3	N. 59 W.	10	10	10	.....	.09
.358	.433	.556	.449	N. NE	NE	E. NE	1.5	3.0	3.0	2.3	N. 50 E	10	8	10	.....	.....
.644	.449	.644	.579	E. NE	NE	Calm..	1.5	3.3	0	1.3	N. 53 E.	10	7	9	.....	.23
.438	.480	.438	.452	W.NW	W.NW	W.NW	4.3	4.8	2.5	3.7	N. 67 W.	1	1	0	.....	.....
.627	.255	.377	.420	W.NW	W.NW	W.NW	1.0	2.3	0.2	1.2	N. 74 W.	0	0	0	.....	.....
.791	.260	.634	.562	W.SW	W. SW	S. SW	0.5	2.5	0.4	1.0	S. 65 W.	0	0	5	.....	.....
.868	.890	.746	.835	Calm..	E. SE	W.NW	0	1.3	0.3	0.3	S. 75 E.	10	10	8	.....	.28
.369	.398	.568	.445	NW	NW	Calm..	4.0	2.5	0	2.2	N. 45 W.	0	0	0	.....	.....
.582	.380	.378	.447	W. SW	W. SW	Calm..	0.4	1.5	0	0.7	S. 73 W.	0	0	0	.....	.....
.712	.628	.890	.743	Calm..	SE....	Calm..	0	0.8	0	0.3	S. 45 E	0	2	2	.....	.....
.496	.527	.527	.517	SE....	E. NE	E. SE	1.3	2.0	1.0	1.2	S. 80 E.	0	2	3	.....	.....
.510	.617	.794	.640	E. NE	E. NE	Calm..	1.0	1.8	0	0.7	N. 81 E.	10	10	8	.....	.03
.550	.628	.703	.627	Calm..	SE....	SE....	0	0.5	0.2	0.2	S. 45 E.	2	3	0	.....	.....
.800	.636	.797	.744	Calm..	E. SE	Calm..	0	0.4	0	0.1	S. 71 E.	10	10	10	.....	.....
.792	.675	.665	.711	Calm..	NE....	NW	0	2.6	0.5	1.0	N. 29 E.	10	9	10	.....	.42
.525	.303	.415	.414	Calm..	E. NE	E	0	0.4	0.8	0.2	N. 82 E	0	0	10	.....	.....
.582	.782	.768	.711	SE	E. SE	E	1.5	3.0	2.1	2.0	S. 70 E	10	10	10	.....	.63
.644	.582	.529	.585	N. NE.	NE	Calm..	0.7	4.0	0	1.6	N. 38 E	10	10	0	.....	.....
.431	.550	.685	.555	Calm..	NW	NW	0	2.0	0.2	0.7	N. 45 W.	0	0	0	.....	.....
.610	.628	.452	.557	NW	NW	NW	1.5	3.6	3.0	2.7	N. 45 W.	0	0	0	.....	.....
.880	.420	.450	.583	NW	W.NW	W.NW	2.5	3.0	0.5	1.7	N. 61 W.	0	0	0	.....	.....
.524	.522	.379	.475	W.NW	W.NW	W	0.2	1.0	0.7	0.7	N. 77 W.	1	9	10	.....	.....
.624	.521	.583	.579	.....	.....	.....	....	....	....	0.4	N. 22 W.	5.3	5.4	5.1	.....	1.81
.617	.550	.559	.572	N. NW	.....	.....	4.0	....	....	1.3	N. 22 W.	9	10	0	.....	.....
.606	.547	.610	.588	.....	.....	E. SE	....	....	0.4	0.1	S. 71 E.	0	5	9	.....	.....
.636	.756	.705	.699	SE	N. NE	N. NE	0.5	0.8	2.0	1.0	N. 19 E.	9	10	10	.....	.22
.895	.726	.712	.778	N. NE	NW .	NW ..	5.3	1.6	3.0	3.0	N. 7 W	10	10	10	.....	.....
.768	.244	.462	.491	NW .	N.NW.	W.SW	3.4	3.4	0.3	2.7	N 57 W.	10	0	0	.....	.04
.510	.386	.420	.439	W.SW	W	W	0.9	4.8	2.3	2.3	S. 87 W.	5	0	10	.....	.....
.527	.357	.712	.532	NW....	E. SE	Calm..	0.1	0.3	0	0.1	East....	1	5	10	.....	.24
.802	.500	.628	.640	NW....	NE....	Calm..	0.2	1.1	0	0.3	N. 35 E	10	3	0	.....	.....
.703	.522	.610	.612	Calm..	Calm..	Calm..	0	0	0	0.0	Calm....	0	2	0	.....	.....
.450	.343	.617	.470	N	N. NE	N. NE	0.5	5.1	2.4	2.7	N. 19 E	10	10	0	.....	.....
.582	.500	.712	.598	Calm..	SE....	Calm..	0	0.8	0	0.3	S. 45 E	0	0	0	.....	.....
.628	.306	.581	.505	Calm..	SW	Calm..	0	2.3	0	0.7	S. 45 W.	0	0	0	.....	.....
.669	.388	.515	.524	Calm..	SE....	Calm..	0	0.7	0	0.2	S. 45 E	0	10	10	.....	.....
.691	.641	.790	.707	Calm..	S.....	S. SE .	0	2.3	1.2	1.0	S. 7 E..	10	10	10	.....	.11
.843	.743	.829	.805	Calm .	Calm..	N. NE.	0	0	1.7	0.7	N. 17 E	10	9	10	.....	.06
.777	.493	.563	.611	N. NE	E. NE	Calm..	2.6	0.5	0	1.0	N. 25 E	10	0	0	.....	.....
.307	.186	.386	.293	N	SE	Calm..	0.5	0.9	0	0.2	S 71 E	0	0	0	.....	.....
.372	.450	.376	.399	E. SE	SE....	S	0.9	1.5	1.0	1.0	S. 38 E	10	5	5	.....	.....
.667	.445	.710	.605	Calm..	SE	Calm..	0	0.5	0	0.1	S. 45 E	8	0	8	.....	.....
.411	.851	.471	.577	W.....	W.NW	NE	3.1	4.5	0.5	2.3	N. 73 W.	0	1	2	.....	.....
.587	.732	.792	.704	SE....	NE	N. NE	0.5	0.9	3.3	0.7	N 79 E	2	9	10	.....	.....
.788	.550	.685	.674	N. NE	N. NE	Calm..	4.8	1.4	0	2.0	N. 22 E	9	10	10	.....	.96
.703	.628	.550	.627	Calm..	E	Calm..	0	0.2	0	0.7	East....	2	5	10	.....	.....
.698	.439	.587	.575	Calm..	W	SW	0	1.1	0.3	0.3	S. 79 W.	9	5	0	.....	.....
.511	.483	.554	.516	W. SW	SW	S. SW	1.6	2.2	0.2	1.3	S. 47 W	5	9	0	.....	.....
.461	.201	.312	.325	S. SW.	W. SW	NW	4.7	5.2	3.1	3.3	S. 63 W.	9	5	0	.....	.....
.582	.463	.408	.484	N.NW.	SE....	Calm..	0.2	2.5	0	0.7	S. 47 E	0	3	0	.....	.10
.488	.439	.587	.505	S.....	SE ..	Calm	0.7	2.7	0	1.0	S. 39 E	0	2	0	.....	.....
.572	.599	.544	.572	S	W.SW	W NW	1.7	7.0	2.2	1.0	S. 67 W.	8	10	0	.....	.....
.577	.386	.705	.556	N. NE.	N. NE	Calm..	3.0	1.6	0	1.7	N. 20 E	10	9	0	.....	.....
.614	.495	.590	.566	.....	.....	.....	....	....	....	0.4	N. 40 W.	5.5	5.2	4.1	.....	1.73

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
May 1	29.270	29.353	29.418	29.347	38	38	32	43	43	35	40.3	44	32	.164	.164	.142	.157
2	29.602	29.616	29.613	29.610	25	30	27	32	37	32	33.7	39	30	.055	.086	.080	.077
3	29.578	29.435	29.173	29.395	32	38	40	37	44	46	42.3	47	28	.116	.151	.169	.145
4	28.986	28.978	29.016	28.993	47	55	54	50	61	57	56.0	65	46	.283	.354	.378	.338
5	29.138	29.230	29.294	29.221	42	43	41	48	52	47	49.0	58	41	.189	.160	.179	.176
6	29.250	29.293	29.441	29.328	36	34	33	41	36	37	38.0	58	35	.147	.170	.136	.151
7	29.376	29.363	29.393	29.377	32	37	35	35	44	38	39.0	46	33	.142	.129	.165	.145
8	.....	29.233	29.190	29.212	....	43	39	....	48	44	46.0	54	32	....	.212	.173	.193
9	29.165	29.160	29.167	29.165	41	46	42	44	52	47	47.7	55	42	.218	.232	.242	.231
10	29.250	29.320	29.305	29.292	43	50	48	46	54	50	50.0	60	44	.248	.308	.309	.285
11	29.415	29.412	29.442	29.423	40	45	46	48	56	48	50.7	59	39	.143	.155	.184	.161
12	29.463	29.343	29.221	29.342	39	38	41	45	46	44	45.0	51	40	.160	.125	.218	.168
13	28.962	28.949	29.029	28.977	41	44	41	43	46	44	44.3	52	43	.231	.262	.218	.237
14	29.112	29.031	29.009	29.051	41	45	41	46	56	43	48.3	59	42	.192	.250	.231	.291
15	29.089	29.154	29.247	29.150	42	41	38	46	46	42	44.7	57	42	.215	.192	.177	.195
16	29.198	29.192	29.275	29.222	38	40	36	41	47	39	42.3	48	37	.190	.156	.173	.173
17	29.445	29.533	29.547	29.508	41	42	41	45	50	47	47.3	53	37	.205	.162	.179	.182
18	29.590	.....	29.480	29.535	42	...	39	51	....	44	47.5	58	39	.149	....	.173	.161
19	29.357	29.285	29.280	29.307	43	44	41	46	47	45	46.0	49	43	.238	.249	.205	.231
20	29.265	29.220	29.179	29.221	41	44	40	43	48	44	45.0	51	43	.231	.236	.195	.221
21	28.922	28.922	29.094	28.979	40	41	40	43	43	43	43.0	48	41	.208	.231	.208	.216
22	29.079	29.092	29.146	29.106	40	43	40	46	54	43	47.7	56	43	.169	.133	.218	.173
23	29.185	29.160	29.162	29.169	40	47	47	48	60	53	53.7	64	40	.143	.152	.214	.180
24	29.133	29.026	29.051	29.070	46	55	50	50	68	53	57.0	70	48	.258	.261	.321	.280
25	28.988	29.026	29.169	29.058	44	46	43	49	57	49	51.7	59	47	.223	.166	.199	.196
26	29.300	29.330	29.370	29.333	41	43	42	46	53	47	48.7	55	40	.192	.146	.242	.193
27	29.410	29.390	29.370	29.390	41	42	43	47	49	46	47.3	56	44	.179	.175	.238	.197
28	29.198	29.072	29.116	29.129	42	42	42	44	44	43	43.7	50	42	.241	.241	.251	.245
29	29.265	29.345	29.390	29.300	44	48	46	48	56	50	51.3	60	46	.236	.239	.258	.241
30	29.412	29.482	29.487	29.460	49	43	41	55	50	45	50.0	60	45	.269	.186	.205	.220
31	29.560	29.495	29.441	29.499	42	44	41	48	52	46	48.7	55	42	.189	.183	.192	.188
Means ..	29.265	29.248	29.273	29.264	40.4	43.0	42.3	48.5	50.0	44.9	46.6	70	28	.194	.201	.210	.201
June 1	29.300	29.131	28.863	29.198	44	47	53	48	50	55	51.0	56	46	.236	.283	.376	.298
2	28.808	28.806	28.882	28.834	57	54	50	63	62	55	60.0	66	54	.386	.312	.295	.331
3	28.996	29.058	29.118	29.054	54	59	53	57	77	58	64.0	81	54	.378	.260	.336	.325
4	29.218	29.284	29.326	29.279	58	49	49	64	56	55	58.3	75	55	.403	.255	.370	.309
5	29.366	29.269	29.193	29.276	51	59	58	57	69	65	63.7	73	51	.295	.367	.389	.350
6	29.115	29.112	29.235	29.154	66	71	58	73	87	64	74.7	90	61	.545	.543	.443	.497
7	29.230	29.233	29.278	29.247	64	70	59	71	75	65	70.3	80	63	.538	.666	.420	.539
8	29.388	29.423	29.416	29.409	53	60	55	56	66	59	60.3	69	51	.363	.432	.340	.397
9	29.458	29.446	29.426	29.443	57	59	53	63	65	56	61.3	71	53	.386	.420	.363	.390
10	29.428	29.358	29.321	29.369	57	61	59	63	75	69	69.0	76	55	.386	.355	.367	.369
11	29.318	29.310	29.303	29.310	63	68	64	67	74	68	69.7	78	65	.522	.604	.543	.556
12	29.335	29.355	29.398	29.363	63	61	66	72	77	68	72.3	85	65	.455	.389	.612	.485
13	29.443	29.395	29.318	29.385	58	65	64	62	75	71	69.3	79	56	.429	.483	.503	.472
14	29.343	29.288	29.248	29.293	62	63	57	67	71	62	66.7	83	62	.489	.469	.397	.452
15	29.195	29.198	29.248	29.214	64	66	58	70	78	67	71.7	82	61	.516	.478	.361	.452
16	29.371	29.396	29.331	29.366	53	56	50	62	65	55	60.7	68	55	.284	.340	.295	.303
17	29.191	29.146	29.356	29.231	62	59	54	68	70	63	67.0	74	54	.476	.354	.286	.376
18	29.488	29.546	29.563	29.532	55	56	54	63	73	62	66.0	75	55	.327	.223	.312	.287
19	29.578	29.501	29.451	29.510	57	68	57	66	74	64	68.0	76	55	.346	.604	.371	.441
20	29.471	29.448	29.468	29.462	54	59	54	59	68	57	61.3	77	56	.351	.380	.378	.370
21	29.471	29.406	29.381	29.419	58	59	62	65	69	68	67.3	75	54	.389	.367	.476	.411
22	29.375	29.358	29.325	29.353	65	68	62	75	78	67	73.3	82	67	.483	.550	.488	.507
23	29.313	29.290	29.270	29.291	64	66	62	70	75	68	71.0	84	64	.516	.519	.476	.504
24	26.140	29.114	29.140	29.131	64	67	66	71	81	73	75.0	86	67	.503	.608	.545	.552
25	29.233	29.218	29.202	29.218	59	65	64	69	81	71	73.7	84	60	.367	.403	.503	.424
26	29.203	29.210	29.100	29.171	63	68	61	71	76	69	72.0	80	64	.469	.577	.480	.492
27	29.195	29.243	29.406	29.281	60	68	51	67	74	55	65.3	77	54	.425	.601	.321	.450
28	29.526	29.521	29.503	29.517	56	60	54	63	70	61	64.7	70	54	.356	.385	.325	.355
29	29.446	29.290	29.185	29.307	61	68	65	69	83	75	75.7	75	55	.430	.483	.483	.465
30	29.152	29.172	29.267	29.197	68	65	57	78	90	65	77.7	92	65	.550	.283	.550	.397
Means ...	29.303	29.284	29.284	29.290	58.7	62.2	57.6	65.6	72.8	63.7	67.4	92	46	.419	.433	.403	.418

the northern and northwestern lakes at Milwaukee, Wisconsin.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
.587	.587	.698	.624	NW.	E.....	N. NE.	1.3	0.7	1.4	0.7	N. 4 W.	8	2	10	.....	.....
.302	.392	.496	.397	N. NE	SE....	Calm..	1.8	1.2	0	0.7	N. 65 E	0	0	0	.....	.....
.527	.522	.543	.531	SE ...	SE ..	SE ...	1.2	1.1	5.0	2.0	S. 45 E	0	10	10	.....	.....
.786	.659	.812	.752	SE....	S. SW.	Calm..	1.3	1.0	0	0.7	S. 17 E	10	10	6	.....	.28
.563	.411	.554	.513	W.SW	W	W.SW	0.3	4.2	0.8	1.7	S. 85 W.	0	5	10	.....	.....
.567	.8 2	.619	.663	NW	Calm..	Calm..	1.0	0	0	0.3	N. 45 W.	9	10	10	.....	.20
.698	.446	.719	.621	N. NW	E	Calm..	0.7	0.6	0	0.3	N. 23 E	5	5	0	.....	.....
...	.631	.597	.614	Calm..	SE ...	Calm..	0	0.5	0	0.2	S. 45 E	0	10	0	.....	.....
.756	.598	.624	.659	Calm..	Calm..	Calm..	0	0	0	0.0	Calm...	10	10	8	.....	.01
.767	.738	.856	.787	N. NE	NW ..	Calm..	0.3	0.2	0	0.1	N. 19 E	10	8	0	.....	.03
.426	.346	.850	.541	Calm..	SE....	Calm..	0	1.5	0	0.6	S. 45 E	0	0	0	.....	.....
.533	.4.0	.756	.563	NE ...	NE ...	NE ...	0.7	2.1	1.3	1.0	N 45 E	0	10	10	.....	.65
.833	.843	.756	.811	N. NE	Calm..	NW	0.2	0	1.6	0.2	N. 17 W	10	10	10	.....	.08
.617	.935	.833	.795	NW ..	W	E. NE	0.8	0.3	0.4	0.2	N. 23 W	0	10	10	.....	.33
.691	.617	.661	.656	NW ..	E. NE	Calm..	0.5	0.8	0	0.2	N. 23 E	0	1	0	.....	.....
.738	.483	.726	.649	NE ...	NE ...	Calm..	0.2	0.8	0	0.3	N. 45 E	9	5	1	.....	.03
.684	.450	.554	.566	NW ..	SE....	Calm..	0.6	0.6	0	0.0	Calm...	0	1	2	.....	.....
.399	.....	.597	.498	SE ...	SE....	N. NE	0.2	1.7	0.5	0.6	S. 67 E	0	10	10	.....	.....
.767	.772	.684	.741	SE...	E	N. NE	0.2	0.2	0.7	0.2	N. 67 E	10	10	10	.....	.10
.833	.704	.677	.738	E. NE	E. NE	NE ...	6.2	0.9	2.0	1.0	N. 55 E	10	10	10	.....	.....
.750	.833	.750	.778	N. NE	N. NE	N	1.2	6.0	2.0	4.7	N. 19 E	10	10	10	.....	1.72
.543	.320	.750	.538	NW ..	N	Calm..	2.5	1.5	0	1.2	N. 27 W.	9	9	8	.....	.....
.426	.293	.606	.442	NW ..	W	Calm..	0.5	2.0	0	0.7	N. 81 W.	0	3	8	.....	.....
.716	.381	.798	.632	S. SW.	S. SW.	W.SW	0.6	3.0	0.2	1.3	S. 21 W.	2	1	10	.....	.40
.638	.358	.572	.523	W.NW	W	Calm..	3.3	3.7	0	2.3	N. 8 W.	0	1	0	.....	.....
.617	.363	.624	.535	NE ...	SE....	Calm..	0.2	0.6	0	0.2	S. 71 E	0	0	0	.....	.....
.554	.5 5	.767	.609	SE....	N. NE	E	0.2	2.5	0.2	1.0	N. 23 E	10	10	10	.....	.38
.836	.836	.916	.863	NE ..	N. NE	Calm..	0.2	1.9	0	0.7	N. 23 E	10	10	10	.....	.18
.704	.512	.716	.644	W	W	Calm..	1.7	1.9	0	1.2	West..	10	9	9	.....	.....
.620	.515	.684	.606	W.NW	NE ...	Calm..	0.7	1.6	0	0.6	N. 15 E	0	0	0	.....	.....
.564	.472	.617	.547	NE ..	E	Calm..	0.2	0.2	0	0.1	N. 71 E	0	3	9	.....	.....
.635	.554	.691	.617	.....	.....	.....	....	....	....	0.3	N. 5 E	4.6	6.2	6.2	.....	4.39
.704	.786	.869	.786	Calm..	NE ...	SE....	0	0.2	0.8	0.2	S. 25 E	10	10	10	.....	.55
.670	.561	.681	.637	SW .	W	W.NW	1.6	4.3	2.6	2.3	S. 88 W.	0	5	10	.....	.....
.812	.281	.698	.597	W.NW	NW .	Calm..	2.2	2.3	0	1.3	N. 55 W.	3	0	0	.....	.....
.675	.569	.620	.621	Calm..	NE ...	Calm..	0	0.2	0	0.1	N. 45 E	9	0	0	.....	.....
.644	.518	.631	.594	Calm..	SE....	Calm..	0	1.5	0	0.1	S. 45 E	0	0	0	.....	.....
.672	.424	.675	.590	SW .	SW .	E.SE	1.4	2.2	0.3	1.0	S. 41 W.	0	2	0	.....	.....
.663	.768	.680	.704	SE....	SE....	Calm..	0.2	1.4	0	0.6	S. 45 E	0	5	0	.....	.08
.809	.685	.761	.752	N. NE	NE ..	NE ..	0.5	0.7	0.2	0.3	N. 27 E	10	0	0	.....	.....
.670	.680	.809	.720	Calm..	Calm..	Calm..	0	0	0	0	Calm ..	0	0	0	.....	.....
.670	.403	.518	.530	Calm..	SE ..	Calm..	0	2.2	0	0.7	S. 45 E.	0	2	9	.....	...
.790	.720	.793	.768	Calm..	S. SW.	Calm..	0	1.0	0	0.2	S. 26 W.	10	9	0	.....	.20
.582	.419	.895	.632	W	E	W.SW	1.5	1.0	0.2	0.2	West ..	0	0	5	.....	.08
.772	.558	.663	.664	Calm..	SE	Calm..	0	1.0	0	0.3	S. 45 E	7	3	0	.....	.61
.740	.618	.716	.692	SW .	E.SE	SE....	0.5	0.7	0.2	0.2	S. 25 E	8	8	8	.....	.....
.704	.499	.550	.584	W.SW	W.NW	Calm..	0.5	1.4	0	0.7	N. 77 W.	1	1	1	.....	.52
.511	.535	.681	.576	N. NE.	.....	.....	2.0	....	....	0.7	N. 21 E	1	2	2	.....	.....
.695	.482	.519	.565	.....	.....	W.NW	....	....	1.3	0.6	N. 75 W.	9	8	2	.....	.....
.568	.276	.561	.468	W	NW .	Calm..	1.2	2.5	0	1.0	N. 55 W.	0	0	0	.....	.....
.543	.720	.625	.629	SW .	SE....	.....	0.2	1.2	....	0.3	S. 41 E	1	2	10	.....	.....
.703	.557	.812	.691	.....	NE	NE	....	0.5	0.6	0.3	N. 45 E	9	5	5	.....	.....
.631	.5 8	.695	.615	E. SE	E.SE	Calm..	1.3	2.8	0	1.3	S. 68 E	0	3	8	.....	.....
.558	.574	.740	.624	Calm..	E.SE	E. SE	0	1.0	0.2	0.3	S. 75 E	7	2	7	.....	.....
.704	.599	.695	.666	NE ...	NE ...	SW .	0.9	0.5	0.3	0.3	N. 45 E	5	8	2	.....	.....
.663	.802	.672	.712	E. SE	W.SW	W.SW	0.5	2.0	0.2	0.7	S. 67 W.	7	7	0	.....	.....
.518	.382	.663	.521	W.SW	SW .	NE	0.5	1.0	0.2	0.3	S. 72 W.	0	1	5	.....	.....
.618	.644	.607	.623	SW	SW .	SW .	0.9	2.5	1.7	2.0	S. 45 W	1	9	0	.....	.....
.642	.720	.743	.702	W. SW	W.SW	N	2.0	2.5	0.9	1.3	S. 81 W.	9	8	9	.....	.....
.619	.525	.606	.583	S	SE ...	S. SE	1.2	2.4	0.5	1.0	S. 37 E	0	0	0	.....	.....
.607	.428	.558	.531	S. SW.	S. SW.	SW .	1.2	3.8	2.6	2.3	S. 29 W	0	0	0	.....	.....
.574	.200	.582	.452	W	W	Calm..	3.2	4.3	0	2.5	West...	0	1	0	.....	.....
.657	.548	.677	.627	.....	.....	.....	....	....	....	0.4	S. 59 W.	3.6	3.7	3.1	.....	2.04

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
July 1	29.355	29.300	29.330	29.328	57	60	58	66	71	65	67.3	76	60	.346	.371	.545	.421
2	29.333	29.267	29.295	29.298	62	70	63	72	81	67	73.3	88	63	.422	.585	.522	.510
3	29.310	29.212	29.150	29.224	67	67	68	75	80	73	76.0	82	65	.554	.487	.618	.553
4	29.145	29.165	29.166	29.159	66	64	56	71	70	58	66.3	75	61	.572	.516	.422	.503
5	29.123	29.186	29.151	29.120	57	60	61	61	62	63	62.0	71	58	.412	.491	.510	.471
6	29.253	29.240	29.233	29.242	63	65	65	66	72	70	69.3	81	62	.536	.524	.550	.535
7	29.413	29.433	29.441	29.429	53	57	57	61	71	65	65.7	75	57	.297	.280	.359	.312
8	29.471	29.421	29.481	29.458	57	59	54	63	68	58	63.0	72	58	.386	.381	.365	.377
9	29.574	29.508	29.398	29.493	54	57	52	58	69	61	62.7	72	50	.365	.316	.289	.323
10	29.248	29.110	29.124	29.161	60	72	71	69	86	80	78.3	89	60	.3 8	.586	.637	.540
11	29.212	29.270	29.347	29.276	62	74	61	70	79	69	72.7	82	69	.449	.772	.43	.550
12	29.486	29.501	29.489	29.492	49	52	46	54	60	52	55.3	70	52	.282	.28	.232	.265
13	29.549	29.514	29.554	29.539	52	55	54	57	64	59	60.0	68	46	.322	.3 4	.351	.329
14	29.451	29.393	29.301	29.382	58	62	57	63	72	64	66 3	74	58	.416	.422	.373	.404
15	29.373	29.418	29.448	29.413	58	57	53	66	75	63	68.0	77	64	.376	.296	.377	.290
16	29.538	29.511	29.491	29.513	56	57	53	66	70	61	65.7	73	55	.316	.293	.297	.302
17	29.508	29.478	29.458	29.481	63	61	57	65	74	65	68.0	77	51	.549	.363	.359	.424
18	29.468	29.448	29.408	29.441	59	60	57	65	70	62	65.7	72	61	.420	.385	.399	.401
19	29.341	29.371	29.426	29.379	58	61	60	64	68	64	65.3	73	61	.403	.443	.465	.437
20	29.491	29.513	29.438	29.481	61	62	59	67	75	67	69.7	77	59	.457	.382	.393	.411
21	29.451	29.458	29.317	29.409	61	64	62	69	79	73	73.7	83	57	.430	.396	.409	.412
22	29.335	29.282	29.272	29.296	67	71	67	75	85	79	79.7	91	67	.574	.57	.501	.538
23	29.312	29.298	29.317	29.309	69	71	68	79	85	75	77.7	90	70	.574	.570	.520	.555
24	29.332	29.289	29.247	29.289	69	71	66	77	82	71	76.7	85	72	.601	.610	.572	.594
25	29.157	29.145	29.200	29.167	68	65	62	71	68	65	68.0	82	65	.644	.577	.516	.579
26	29.255	29.250	29.208	29.238	63	67	63	67	73	78	72.7	77	61	.522	.581	.575	.593
27	29.173	29.105	29.044	29.107	66	71	71	72	80	78	76.7	89	62	.559	.657	.664	.626
28	29.127	29.167	29.360	29.218	67	62	57	74	80	66	73.3	84	66	.562	.316	.316	.410
29	29.531	29.538	29.548	29.536	51	59	56	61	71	63	65.0	73	55	.242	.34	.376	.313
30	29.553	29.448	29.345	29.449	58	61	59	66	76	67	69.7	77	57	.376	.346	.393	.372
31	29.213	29.173	29.138	29.175	60	62	62	65	82	69	72.0	83	61	.451	.229	.462	.401
Means....	29.357	29.333	29.326	29.339	60.4	63.1	59.9	66.9	74.1	66.8	69.2	91	46	.445	.440	.437	.441
August 1	29.120	29.163	29.220	29.168	60	63	59	65	71	66	67.3	76	60	.451	.469	.407	.442
2	29.301	29.355	29.381	29.346	60	63	58	65	69	61	65.0	73	59	.451	.495	.443	.463
3	29.451	29.418	29.430	29.433	59	64	60	63	71	69	67.7	75	55	.447	.503	.398	.449
4	29.485	29.475	29.480	29.480	63	69	67	72	84	74	76.7	87	65	.455	.507	.568	.510
5	29.530	29.519	29.492	29.514	66	69	67	73	81	71	75.0	87	66	.545	.547	.6 8	.597
6	29.497	29.439	29.427	29.454	67	70	65	73	88	73	78.0	90	66	.581	.491	.510	.527
7	29.470	29.412	29.374	29.419	68	68	66	75	81	74	76.7	89	67	.591	.510	.532	.511
8	29.385	29.312	29.302	29.333	69	69	66	77	82	76	78.3	85	70	.611	.534	.505	.547
9	29.332	29.354	29.475	29.387	69	68	61	77	73	64	71.3	94	64	.601	.618	.497	.572
10	29.583	29.618	29.593	29.598	58	58	55	63	74	62	66.3	90	57	.416	.270	.340	.342
11	29.603	29.413	29.413	29.476	57	63	57	63	*75	65	67.7	79	54	.399	.415	.359	.391
12	29.243	29.107	29.132	29.161	69	72	68	70	89	70	79.7	90	61	.385	.355	.65[illegible]	.466
13	29.220	29.268	29.298	29.262	59	60	59	63	68	62	64.3	72	61	.447	.471	.46[illegible]	.459
14	29.358	29.363	29.380	29.367	58	64	60	64	73	68	68.3	82	58	.403	.476	.411	.430
15	29.508	29.480	29.445	29.478	62	65	61	64	75	64	[illegible]7	76	61	.529	.483	.497	.503
16	29.428	29.343	29.260	29.344	62	66	65	68	76	72	[illegible].0	78	59	.476	.505	.524	.502
17	29.190	29.134	29.124	29.149	68	70	64	76	91	76	81.0	93	70	.577	.451	.436	.488
18	29.220	29.224	29.302	29.249	64	64	63	72	82	67	73.7	86	67	.489	.349	.522	.453
19	29.490	29.425	29.418	29.444	62	64	60	66	72	64	67.3	73	64	.502	.429	.465	.465
20	29.473	29.435	29.413	29.440	58	63	60	62	75	68	68.3	76	55	.429	.549	.411	.463
21	29.408	29.315	29.297	29.340	59	67	64	68	82	73	74.3	85	65	.380	.469	.476	.442
22	29.285	29.167	29.162	29.205	65	72	68	72	89	78	79.7	91	67	.524	.555	.55[illegible]	.543
23	29.159	29.162	29.227	29.183	66	76	60	75	85	71	77.0	87	71	.519	.773	.371	.554
24	29.395	29.438	29.456	29.430	57	57	54	63	67	58	62.7	73	59	.386	.333	.365	.361
25	29.468	29.469	29.423	29.453	59	65	61	64	73	65	67.3	76	51	.431	.510	.483	.475
26	29.388	29.359	29.298	29.339	61	67	65	65	74	71	70.0	78	61	.463	.568	.537	.523
27	29.240	29.062	29.187	29.116	64	68	67	67	74	71	70.7	80	67	.536	.604	.6[illegible]	.616
28	29.251	29.261	29.306	29.273	52	55	51	61	73	61	65.0	57	59	.369	.194	.242	.335
29	29.401	29.421	29.5 4	29.445	49	51	49	56	67	56	59.7	69	51	.255	.163	.255	.224
30	29.572	29.509	29.379	29.487	47	53	54	53	66	60	59.7	69	43	.244	.231	.338	.271
31	29.193	29.105	29.276	29.191	59	63	59	62	68	57	62.3	72	56	.460	.369	.[illegible]68	.412
Means....	29.374	29.339	29.348	29.354	60.9	64.7	60.8	67.0	76.4	67.3	70.2	94	43	.46[illegible]	.462	.432	.458

the northern and northwestern lakes at Milwaukee, Wisconsin.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.543	.490	.672	.568	.....	.....	.....	...	...	...	...	.....	2	9	0	.....	.....
.539	.554	.790	.628	.....	.....	.....	...	...	...	...	.....	0	9	9	.....	.36
.639	.476	.761	.625	.....	.....	.....	...	...	...	...	.....	2	1	1	.....	.10
.754	.774	.876	.778	.....	.....	.....	...	...	...	...	.....	10	5	10	.....	.....
.769	.884	.886	.846	.....	.....	.....	...	...	...	...	.....	10	10	10	.....	.....
.898	.668	.751	.752	.....	.....	.....	...	...	...	...	.....	0	9	8	.....	.62
.553	.369	.582	.501	.....	.....	.....	...	...	...	...	.....	0	1	0	.....	.....
.670	.557	.756	.661	.....	.....	.....	...	...	...	...	.....	3	9	0	.....	.....
.756	.432	.502	.563	.....	.....	.....	...	...	...	...	.....	0	0	0	.....	.01
.564	.480	.623	.556	.....	.....	.....	...	...	...	...	.....	5	2	8	.....	.....
.613	.779	.607	.666	.....	.....	.....	...	...	...	...	.....	9	8	1	.....	.....
.674	.546	.598	.606	.....	.....	.....	...	...	...	...	.....	1	0	0	.....	.06
.692	.527	.703	.641	.....	.....	.....	...	...	...	...	.....	0	0	3	.....	.....
.723	.539	.625	.629	.....	.....	.....	...	...	...	...	.....	7	1	5	.....	.....
.588	.261	.470	.440	.....	.....	.....	...	...	...	...	.....	1	3	0	.....	.10
.495	.400	.553	.483	.....	.....	.....	...	...	...	...	.....	0	0	0	.....	.....
.890	.433	.582	.635	.....	.....	.....	...	...	...	...	.....	0	5	3	.....	.....
.680	.525	.718	.641	.....	.....	.....	...	...	...	...	.....	9	7	2	.....	.....
.675	.647	.780	.701	.....	.....	.....	...	...	...	...	.....	10	8	5	.....	.....
.690	.441	.595	.575	.....	.....	.....	...	...	...	...	.....	1	0	0	.....	.....
.617	.400	.574	.504	.....	.....	.....	...	...	...	...	.....	0	1	0	.....	.....
.639	.474	.506	.540	.....	.....	.....	...	...	...	...	.....	0	2	0	.....	.....
.580	.474	.681	.578	.....	.....	.....	...	...	...	...	.....	0	5	1	.....	.....
.648	.559	.754	.654	.....	.....	.....	...	...	...	...	.....	9	10	10	.....	.....
.850	.843	.836	.843	.....	.....	.....	...	...	...	...	.....	10	10	0	.....	.78
.790	.716	.392	.633	.....	.....	.....	...	...	...	...	.....	0	0	0	.....	.....
.712	.623	.693	.676	.....	.....	.....	...	...	...	...	.....	1	5	5	.....	.....
.677	.309	.544	.510	.....	.....	.....	...	...	...	...	.....	3	4	1	.....	.05
.452	.449	.619	.507	.....	.....	.....	...	...	...	...	.....	0	1	0	.....	.....
.588	.375	.595	.519	.....	.....	.....	...	...	...	...	.....	8	3	2	.....	.....
.731	.265	.653	.550	.....	.....	.....	...	...	...	...	.....	1	2	9	.....	.52
.665	.523	.652	.613	.....	.....	.....	...	...	...	...	.....	3.3	4.2	3.0	.....	2.60
.731	.618	.636	.662	.....	.....	.....	...	...	...	...	.....	0	5	5	.....	.....
.731	.700	.825	.752	.....	.....	.....	...	...	...	...	.....	0	0	0	.....	.....
.776	.663	.564	.668	.....	.....	.....	...	...	...	...	.....	0	1	0	.....	.....
.582	.435	.677	.565	.....	.....	.....	...	...	...	...	.....	5	5	0	.....	.....
.672	.518	.802	.664	.....	.....	.....	...	...	...	...	.....	0	5	9	.....	.04
.716	.371	.629	.572	.....	.....	.....	...	...	...	...	.....	1	2	0	.....	.....
.681	.483	.634	.599	.....	.....	.....	...	...	...	...	.....	0	2	0	.....	.....
.648	.489	.563	.567	.....	.....	.....	...	...	...	...	.....	0	2	0	.....	.....
.648	.761	.833	.747	.....	.....	.....	...	...	...	...	.....	0	5	0	.....	.....
.723	.332	.612	.552	.....	.....	.....	...	...	...	...	.....	0	0	0	.....	.....
.718	.479	.582	.593	.....	.....	.....	...	...	...	...	.....	0	0	0	.....	.....
.525	.407	.898	.610	.....	.....	.....	...	...	...	...	.....	0	10	10	.....	1.19
.776	.601	.828	.735	.....	.....	.....	...	...	...	...	.....	10	0	0	.....	.....
.675	.588	.601	.621	.....	.....	.....	...	...	...	...	.....	0	8	3	.....	.....
.888	.558	.833	.760	.....	.....	.....	...	...	...	...	.....	10	5	9	.....	.....
.695	.563	.668	.642	.....	.....	.....	...	...	...	...	.....	3	0	5	.....	.....
.644	.310	.486	.480	.....	.....	.....	...	...	...	...	.....	1	0	0	.....	.....
.624	.315	.790	.576	.....	.....	.....	...	...	...	...	.....	0	7	3	.....	.....
.786	.624	.780	.730	.....	.....	.....	...	...	...	...	.....	10	5	0	.....	.05
.772	.890	.601	.754	.....	.....	.....	...	...	...	...	.....	0	0	0	.....	.....
.557	.422	.588	.522	.....	.....	.....	...	...	...	...	.....	0	0	5	.....	.....
.668	.477	.574	.550	.....	.....	.....	...	...	...	...	.....	3	1	5	.....	.....
.599	.644	.490	.578	.....	.....	.....	...	...	...	...	.....	1	0	0	.....	.....
.670	.503	.756	.643	.....	.....	.....	...	...	...	...	.....	1	0	0	.....	.....
.727	.629	.783	.713	.....	.....	.....	...	...	...	...	.....	0	0	0	.....	.....
.783	.677	.708	.723	.....	.....	.....	...	...	...	...	.....	1	0	0	.....	.....
.841	.720	.802	.788	.....	.....	.....	...	...	...	...	.....	10	10	0	.....	.20
.502	.240	.452	.398	.....	.....	.....	...	...	...	...	.....	0	0	0	.....	.....
.569	.246	.569	.461	.....	.....	.....	...	...	...	...	.....	2	1	0	.....	.....
.606	.361	.653	.540	.....	.....	.....	...	...	...	...	.....	0	0	0	.....	.....
.828	.743	.577	.716	.....	.....	.....	...	...	...	...	.....	10	2	10	.....	.53
.689	.525	.670	.628	.....	.....	.....	...	...	...	...	.....	2.2	2.4	2.1	.....	2.01

Reductions of the monthly meteorological register of the surveyo

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					o	o	o	o	o	o	o	o	o				
Sept. 1	29.412	29.434	29.402	29.416	46	49	45	50	57	48	51.7	62	46	.258	.242	.260	.253
2	29.375	29.266	29.198	29.280	48	59	58	51	72	65	62.7	73	43	.296	.327	.389	.337
3	29.276	29.246	29.302	29.275	52	55	51	55	69	58	60.7	71	53	.349	.247	.292	.293
4	29.369	29.311	29.258	29.313	49	59	57	53	69	63	61.7	71	49	.295	.367	.346	.336
5	29.136	29.000	29.118	29.085	64	69	65	68	83	68	73.0	84	62	.543	.52	.577	.547
6	29.386	29.445	29.549	29.460	48	52	51	54	62	54	56.7	69	49	.258	.256	.335	.292
7	29.659	19.654	29.594	29.636	47	56	52	50	64	55	56.3	66	46	.283	.343	.349	.325
8	29.516	29.398	29.296	29.403	52	61	58	56	70	65	63.7	74	50	.335	.416	.389	.380
9	29.346	29.416	29.487	29.416	49	53	50	54	61	53	56.0	71	53	.282	.297	.321	.300
10	29.602	29.544	29.484	29.543	43	51	48	47	61	52	53.3	63	44	.225	.242	.292	.253
11	29.427	29.286	29.239	29.317	47	58	52	51	71	60	60.7	72	46	.270	.336	.282	.296
12	29.226	29.153	29.110	29.163	51	65	60	56	79	67	67.3	81	54	.308	.431	.425	.388
13	29.136	29.342	29.462	29.313	53	52	50	55	60	55	56.7	71	53	.376	.282	.245	.318
14	29.542	29.509	29.446	29.499	49	56	56	45	62	60	55.7	64	52	....	.369	.396	.383
15	29.379	29.248	29.248	29.292	56	64	68	61	72	73	68.7	76	58	.383	.489	.618	.497
16	29.323	29.287	29.342	29.317	68	73	70	72	87	80	79.7	90	70	.611	.623	.598	.611
17	29.482	19.427	29.452	29.454	69	74	70	75	89	79	81.0	91	74	.622	.637	.612	.636
18	29.434	29.600	29.586	29.540	67	57	56	72	61	60	64.3	82	60	.595	.412	.396	.468
19	29.503	29.328	29.312	29.381	58	73	69	61	86	76	74.3	87	59	.443	.639	.614	.564
20	29.453	29.525	29.601	29.593	58	58	51	62	69	58	63.0	79	57	.429	.336	.292	.349
21	29.654	29.576	29.583	29.604	50	55	52	54	70	57	60.3	78	49	.308	.531	.322	.387
22	29.556	29.564	29.593	29.571	51	60	57	57	75	61	64.3	79	56	.295	.318	.412	.342
23	.....	29.643	29.648	29.646	....	60	57	....	69	62	65.5	70	54	.....	.388	.389	.389
24	29.508	29.408	29.085	29.334	55	62	57	62	80	68	70.0	81	57	.340	.316	.319	.325
25	29.518	29.622	29.610	29.583	49	47	46	59	55	52	55.3	83	50	.216	.217	.232	.222
26	29.632	29.562	29.497	29.564	50	50	44	54	59	47	52.3	60	47	.308	.242	.249	.266
27	29.412	19.337	29.292	29.547	53	55	52	59	64	57	60.0	66	41	.323	.314	.322	.320
28	29.242	29.143	29.165	29.183	52	64	62	55	82	68	68.3	85	51	.349	.355	.476	.393
29	29.439	29.537	29.600	29.525	48	45	41	54	53	47	51.3	70	47	.256	.194	.179	.210
30	29.637	29.530	29.420	29.529	36	46	42	40	54	46	46.7	56	40	.160	.206	.215	.194
Means....	29.434	29.412	29.399	29.419	49.4	57.9	54.9	56.6	68.8	60.5	62.0	91	40	.348	.360	.374	.363
Oct. 1	29.307	29.088	29.013	29.136	41	53	51	48	71	66	61.7	74	45	.166	.164	.176	.169
2	29.078	29.229	29.332	29.213	52	51	47	56	60	53	56.3	67	53	.355	.255	.244	.272
3	29.452	29.377	29.392	29.407	45	46	41	52	54	45	50.3	57	45	.207	.206	.225	.205
4	29.375	29.270	29.262	29.302	38	47	46	41	52	50	47.7	55	40	.190	.257	.226	.235
5	29.327	29.462	29.610	29.466	45	46	43	48	54	46	49.3	55	46	.260	.206	.228	.235
6	29.762	29.760	29.757	29.760	38	50	45	41	56	51	49.3	57	44	.190	.282	.239	.237
7	29.825	29.750	29.637	29.731	44	49	48	47	58	54	53.0	60	43	.249	.229	.256	.245
8	29.560	29.377	29.209	29.382	42	53	51	47	60	60	55.7	63	43	.202	.310	.253	.255
9	28.928	28.878	28.851	28.886	49	48	46	54	61	56	57.0	63	52	.282	.164	.179	.208
10	28.836	28.886	29.018	28.913	45	45	44	51	51	49	50.3	58	49	.220	.220	.223	.221
11	29.133	29.227	29.320	29.260	43	45	44	47	51	49	49.0	63	46	.225	.220	.223	.223
12	29.417	29.445	29.487	29.450	37	48	42	42	55	44	47.0	56	42	.153	.243	.241	.212
13	29.517	29.462	29.442	29.474	37	57	41	39	63	45	49.0	64	37	.194	.286	.205	.262
14	29.427	29.344	29.332	29.368	39	52	46	42	67	55	54.7	69	41	.199	.190	.192	.194
15	29.397	29.377	29.364	29.379	42	52	46	45	60	55	53.2	62	45	.282	.282	.192	.252
16	29.392	29.321	29.333	29.349	52	61	57	55	78	64	65.7	80	53	.349	.310	.373	.344
17	29.231	29.206	29.261	29.233	57	63	56	65	75	62	67.3	75	62	.359	.415	.369	.381
18	29.261	29.206	29.233	29.233	47	61	56	52	70	61	61.0	76	51	.257	.416	.383	.352
19	29.286	29.253	29.291	29.277	57	66	57	60	75	68	67.7	80	57	.436	.519	.319	.425
20	29.376	29.311	29.301	29.329	56	58	52	59	77	64	66.7	78	58	.409	.230	.229	.289
21	29.308	29.399	29.544	29.417	51	47	40	54	50	46	50.0	66	46	.335	.269	.169	.258
22	29.692	29.677	29.770	29.713	36	45	33	39	55	39	44.3	56	39	.173	.168	.110	.150
23	29.857	29.814	29.792	29.821	30	41	37	34	55	41	43.3	56	32	.121	.074	.169	.121
24	29.803	29.750	29.670	29.741	32	47	43	35	53	50	46.0	56	36	.142	.244	.186	.191
25	29.652	29.630	29.610	29.631	43	49	47	48	51	50	49.7	55	47	.212	.321	.283	.272
26	29.610	29.600	29.607	29.606	42	48	47	52	51	49	50.7	56	47	.262	.286	.297	.282
27	29.640	29.612	29.594	29.615	43	49	48	45	55	51	50.3	56	45	.231	.269	.286	.272
28	29.680	29.560	29.542	29.594	46	47	39	47	56	44	49.0	56	44	.297	.204	.173	.225
29	29.470	29.412	29.447	29.443	34	38	34	36	42	37	38.3	55	35	.170	.177	.157	.168
30	29.392	29.348	29.320	28.354	31	31	41	34	37	44	38.3	44	34	.139	.105	.218	.154
31	29.537	29.493	29.406	29.479	34	43	39	38	39	44	43.7	52	36	.144	.199	.173	.172
Means....	29.436	29.404	29.411	29.417	43.0	49.5	45.4	46.9	58.1	51.7	52.2	80	32	.238	.253	.232	.241

the northern and northwestern lakes at Milwaukee, Wisconsin.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.716	.521	.777	.671	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.790	.417	.631	.613	.....	.....	.....	....	....	....	....	.....	1	2	0	.....	.29
.805	.350	.584	.580	.....	.....	.....	....	....	....	....	.....	1	0	0	.....	.....
.733	.518	.670	.640	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.793	.461	.843	.699	.....	.....	.....	....	....	....	....	.....	0	2	10	.....	.68
.613	.461	.802	.625	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.786	.575	.805	.722	.....	.....	.....	....	....	....	....	.....	0	5	0	.....	.....
.747	.570	.631	.649	.....	.....	.....	....	....	....	....	.....	0	1	8	.....	.06
.674	.553	.798	.675	.....	.....	.....	....	....	....	....	.....	1	8	1	.....	.....
.698	.452	.727	.626	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.722	.475	.546	.581	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.687	.434	.642	.588	.....	.....	.....	....	....	....	....	.....	0	8	9	.....	.....
.869	.546	.681	.699	.....	.....	.....	....	....	....	....	.....	10	0	0	.....	.06
.....	.665	.765	.715	.....	.....	.....	....	....	....	....	.....	0	8	5	.....	.....
.713	.624	.761	.699	.....	.....	.....	....	....	....	....	.....	0	5	0	.....	.....
.804	.486	.585	.625	.....	.....	.....	....	....	....	....	.....	5	3	5	.....	.....
.724	.466	.618	.603	.....	.....	.....	....	....	....	....	.....	9	5	10	.....	.....
.758	.769	.765	.764	.....	.....	.....	....	....	....	....	.....	8	10	10	.....	.....
.825	5'3	.685	.674	.....	.....	.....	....	....	....	....	.....	10	5	8	.....	.02
.772	.475	.584	.610	.....	.....	.....	....	....	....	....	.....	9	10	0	.....	.35
.738	.442	.692	.624	.....	.....	.....	....	....	....	....	.....	0	1	0	.....	.....
.634	.367	.769	.590	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.....	.564	.718	.641	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.612	.309	.467	.463	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.432	.502	.598	.511	.....	.....	.....	....	....	....	....	.....	0	0	8	.....	.....
.738	.484	.772	.665	.....	.....	.....	....	....	....	....	.....	10	2	2	.....	.....
.647	.527	.692	.622	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.805	.326	.695	.609	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.613	.483	.554	.550	.....	.....	.....	....	....	....	....	.....	1	5	0	.....	.....
.645	.493	.691	.610	.....	.....	.....	....	....	....	....	.....	2	0	0	.....	.....
.718	.494	.685	.631	.....	.....	.....	....	....	....	....	.....	2.2	2.7	2.5	.....	1.46
.494	.217	.276	.329	.....	.....	.....	....	....	....	....	.....	2	7	0	.....	.....
.747	.493	.606	.615	.....	.....	.....	....	....	....	....	.....	9	10	5	.....	.....
.535	.493	.684	.571	.....	.....	.....	....	....	....	....	.....	10	10	0	.....	.....
.738	.660	.716	.705	.....	.....	.....	....	....	....	....	.....	0	0	10	.....	.01
.777	.493	.767	.679	.....	.....	.....	....	....	....	....	.....	8	9	8	.....	.....
.738	.627	.590	.652	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.772	.475	.613	.620	.....	.....	.....	....	....	....	....	.....	8	9	0	.....	.....
.624	.599	.493	.572	.....	.....	.....	....	....	....	....	.....	0	1	3	.....	.....
.764	.306	.399	.490	.....	.....	.....	....	....	....	....	.....	2	10	5	.....	.17
.590	.590	.638	.606	.....	.....	.....	....	....	....	....	.....	10	10	10	.....	.....
.698	.590	.638	.642	.....	.....	.....	....	....	....	....	.....	10	10	10	.....	.....
.577	.561	.836	.658	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.816	.670	.684	.723	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.744	.287	.445	.492	.....	.....	.....	....	....	....	....	.....	1	0	0	.....	.....
.762	.546	.445	.584	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.809	.324	.625	.586	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.582	.479	.665	.575	.....	.....	.....	....	....	....	....	.....	2	5	2	.....	.....
.660	.570	.713	.648	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.822	.599	.467	.629	.....	.....	.....	....	....	....	....	.....	10	5	0	.....	.....
.919	.248	.385	.484	.....	.....	.....	....	....	....	....	.....	0	5	0	.....	.....
.802	.786	.543	.710	.....	.....	.....	....	....	....	....	.....	10	10	3	.....	.28
.726	.388	.463	.592	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.617	.171	.653	.480	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.698	.606	.515	.606	.....	.....	.....	....	....	....	....	.....	0	0	10	.....	.....
.631	.859	.786	.753	.....	.....	.....	....	....	....	....	.....	10	10	10	.....	.20
.727	.790	.853	.790	.....	.....	.....	....	....	....	....	.....	2	10	10	.....	.....
.840	.620	.790	.750	.....	.....	.....	....	....	....	....	.....	3	9	0	.....	.....
.923	.455	.597	.658	.....	.....	.....	....	....	....	....	.....	10	0	0	.....	.....
.802	.661	.712	.725	.....	.....	.....	....	....	....	....	.....	0	10	10	.....	.12
.712	.476	.756	.648	.....	.....	.....	....	....	....	....	.....	9	10	10	.....	.02
.628	.572	.597	.599	.....	.....	.....	....	....	....	....	.....	10	0	0	.....	.....
.717	.526	.611	.618	.....	.....	.....	....	....	....	....	.....	4.1	4.8	3.4	.....	.80

Reductions of the monthly meteorological register of the surveyo

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Nov. 1	29.197	28.946	28.996	29.046	41	51	50	49	65	58	57.3	67	45	.130	.189	.255	.191
2	29.154	29.164	29.116	29.145	43	44	41	52	55	49	52.0	60	50	.160	.144	.153	.152
3	28.677	28.632	29.013	28.784	49	43	34	52	47	37	45.3	56	37	.308	.225	.157	.230
4	29.362	29.533	29.647	29.521	30	31	28	34	41	33	36.0	43	33	.121	.059	.096	.092
5	29.642	29.740	29.693	29.692	30	45	32	35	48	37	40.0	50	32	.1 9	.261	.116	.165
6	29.618	29.565	29.297	29.437	28	45	40	32	53	50	45.0	56	32	.108	.194	.117	.140
7	29.111	28.923	28.858	28.997	38	46	45	46	50	52	49.3	62	46	.125	.258	.207	.197
8	28.751	28.790	28.858	28.800	52	51	41	57	64	49	56.7	64	51	.322	.316	.153	.264
9	28.978	29.015	29.132	29.042	34	39	36	40	53	46	46.3	54	40	.118	.055	.092	.085
10	29.247	29.295	29.387	29.310	31	34	27	36	36	34	35.7	49	35	.116	.040	.067	.074
11	29.427	29.508	29.631	29.555	21	28	26	26	34	31	30.3	39	26	.056	.085	.083	.075
12	29.734	29.659	29.458	29.617	20	31	28	23	38	36	32.3	40	23	.074	.093	.062	.076
13	29.415	29.335	29.129	29.293	27	40	39	32	46	46	41.3	47	32	.090	.169	.147	.135
14	29.253	29.361	29.5 8	29.381	33	36	28	38	49	44	43.3	50	34	.123	.042	.085	.083
15	29.571	29.333	29.232	29.379	24	38	38	27	51	50	42.7	53	27	.095	.059	.072	.075
16	29.315	29.580	29.522	29.542	29	34	32	35	43	38	38.7	52	35	.091	.079	.103	.091
17	29.363	29.343	29.450	29.385	30	37	35	36	45	39	40.0	49	35	.098	.116	.152	.122
18	29.508	29.483	29.528	29.506	24	26	26	29	35	33	32.3	41	27	.072	.038	.061	.057
19	29.573	29.462	29.403	29.479	28	36	32	33	43	37	37.7	45	32	.096	.121	.116	.111
20	29.328	29.332	29.402	29.354	32	46	37	38	58	41	45.3	60	35	.103	.153	.181	.146
21	29.340	29.227	29.240	29.269	32	51	43	36	59	48	47.7	61	31	.129	.269	.212	.203
22	29.237	29.189	29.224	29.217	41	52	46	44	61	49	51.3	62	40	.218	.369	.271	.253
23	29.292	29.235	29.169	29.232	39	46	51	41	49	54	48.0	55	42	.212	.271	.335	.273
24	29.111	29.123	29.139	29.121	51	57	52	53	61	55	56.3	61	54	.348	.412	.347	.370
25	29.124	29.207	29.338	29.223	34	33	32	36	36	37	36.3	56	35	.170	.149	.116	.145
26	29.478	29.501	29.518	29.509	27	35	31	29	41	34	34.7	42	29	.124	.126	.139	.130
27	29.478	29.343	29.338	29.386	34	37	34	37	41	37	38.3	43	32	.157	.168	.157	.161
28	29.343	29.256	29.195	29.265	29	35	36	31	37	38	35.3	43	31	.137	.178	.186	.167
29	29.102	29.127	29.340	29.190	25	15	7	27	18	9	18.0	41	9	.112	.052	.077	.080
30	29.541	29.548	29.482	29.520	1	11	9	2	14	11	09.0	29	1	.034	.037	.043	.038
Means....	29.316	29.287	29.310	29.304	31.9	38.4	34.5	36.2	46.0	40.0	40.7	67	1	.138	.151	.143	.145
Dec. 1	29.355	29.304	29.304	29.321	17	25	24	20	29	27	25.3	31	13	.060	.089	.095	.081
2	29.346	29.461	29.546	29.448	24	27	23	29	33	27	29.7	35	27	.072	.090	.078	.080
3	29.491	29.368	29.418	29.4 6	28	24	17	33	31	21	29.3	56	20	.096	.049	.049	.065
4	29.318	29.181	29.114	29.204	14	22	23	18	28	25	24.7	30	15	.037	.050	.100	.062
5	29.211	29.217	28.994	29.141	19	24	28	22	28	31	27.0	32	20	.069	.083	.119	.090
6	28.553	28.829	29.291	28.891	36	24	15	40	31	19	30.0	44	19	.160	.049	.040	.083
7	29.530	29.572	29.652	29.585	4	11	9	7	16	13	12.0	24	6	.018	.014	.029	.020
8	29.753	29.679	29.705	29.712	4	16	14	6	22	17	15.0	24	6	.030	.022	.048	.033
9	29.589	29.321	29.293	29.401	17	30	31	20	37	34	30.3	39	15	.061	.086	.139	.095
10	29.301	29.293	29.254	29.283	24	25	25	29	27	27	27.7	36	26	.072	.112	.142	.099
11	29.234	29.243	29.291	29.256	29	26	25	30	28	28	28.7	34	27	.149	.117	.100	.122
12	29.358	29.445	29.536	29.446	17	18	20	21	21	22	21.3	32	20	.049	.065	.085	.066
13	29.507	29.399	29.376	29.427	19	21	22	22	24	25	23.6	30	21	.069	.079	.084	.077
14	29.343	29.354	29.393	29.360	23	22	19	25	26	23	24.7	28	20	.100	.072	.058	.077
15	29.364	29.276	29.238	29.293	14	24	22	16	27	25	22.7	30	15	.059	.095	.084	.079
16	29.168	28.989	28.974	29.040	24	31	31	26	35	34	31.7	36	25	.106	.128	.139	.124
17	29.047	29.194	29.371	29.204	27	25	22	31	29	25	28.3	38	25	.101	.089	.084	.091
18	29.594	29.674	29.774	29.681	15	23	14	18	27	16	20.3	27	15	.052	.078	.139	.089
19	29.711	29.583	29.361	29.552	21	26	29	23	31	31	28.3	35	15	.094	.083	.137	.105
20	29.346	29.541	29.646	29.511	28	25	16	31	29	19	26.3	34	19	.119	.089	.056	.088
21	29.504	29.107	28.864	29.158	31	32	38	33	34	39	35.3	43	15	.151	.155	.216	.174
22	28.957	29.134	29.378	29.143	30	24	18	31	28	21	26.7	42	21	.155	.083	.065	.101
23	29.692	29.684	29.449	29.608	3	14	17	4	17	20	13.7	23	3	.038	.048	.061	.049
24	29.214	29.216	29.223	29.218	28	34	34	32	40	36	36.0	44	21	.108	.118	.170	.132
25	28.916	28.677	29.101	28.895	40	47	31	42	49	36	42.3	50	36	.221	.297	.116	.211
26	29.366	29.226	28.972	29.188	22	31	36	25	33	38	32.0	50	24	.084	.131	.186	.140
27	28.849	28.984	29.356	29.063	35	33	13	38	39	16	31.0	42	16	.165	.110	.044	.106
28	29.524	29.531	29.596	29.554	11	18	14	13	23	17	17.7	24	13	.049	.042	.048	.046
29	29.404	29.840	29.883	29.842	7	15	12	10	19	14	14.3	21	9	.026	.040	.052	.039
30	29.981	29.941	29.796	29.906	6	16	12	8	20	14	14.0	21	8	.034	.044	.052	.043
31	29.632	29.376	29.156	29.388	18	26	31	19	32	34	28.3	36	9	.087	.072	.139	.099
Means....	29.382	29.354	29.376	29.371	20.5	24.5	22.1	23.4	28.8	25.0	25.7	56	3	.087	.087	.091	.088

the northern and northwestern lakes at Milwaukee, Wisconsin.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.373	.307	.529	.403	.....	.....	.....	....	....	....	....	.....	1	3	0	.....	.....
.411	.333	.439	.394	.....	.....	.....	....	....	....	....	.....	1	8	10	.....	.....
.794	.698	.712	.735	.....	.....	.....	....	....	....	....	.....	10	10	1	.....	.....
.617	.229	.510	.452	.....	.....	.....	....	....	....	....	.....	1	0	0	.....	.....
.537	.777	.527	.614	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.594	.483	.322	.466	.....	.....	.....	....	....	....	....	.....	5	2	0	.....	.....
.400	.716	.535	.550	.....	.....	.....	....	....	....	....	.....	5	2	0	.....	.....
.692	.351	.439	.494	.....	.....	.....	....	....	....	....	.....	3	8	3	.....	.....
.476	.137	.260	.291	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.550	.127	.340	.339	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.397	.432	.480	.436	.....	.....	.....	....	....	....	....	.....	0	9	5	.....	.....
.598	.408	.291	.432	.....	.....	.....	....	....	....	....	.....	0	5	0	.....	.....
.496	.543	.471	.503	.....	.....	.....	....	....	....	....	.....	0	0	9	.....	.....
.537	.120	.432	.363	.....	.....	.....	....	....	....	....	.....	1	1	0	.....	.....
.644	.157	.199	.333	.....	.....	.....	....	....	....	....	.....	2	1	0	.....	.....
.448	.283	.450	.394	.....	.....	.....	....	....	....	....	.....	8	1	8	.....	.....
.462	.386	.636	.495	.....	.....	.....	....	....	....	....	.....	3	1	2	.....	.....
.449	.185	.322	.319	.....	.....	.....	....	....	....	....	.....	9	10	10	.....	.....
.510	.433	.527	.490	.....	.....	.....	....	....	....	....	.....	10	9	0	.....	.....
.450	.318	.732	.497	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.610	.537	.631	.593	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.756	.502	.781	.680	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.06
.824	.781	.802	.802	.....	.....	.....	....	....	....	....	.....	0	9	10	.....	.35
.864	.769	.805	.813	.....	.....	.....	....	....	....	....	.....	10	10	5	.....	.....
.802	.705	.527	.678	.....	.....	.....	....	....	....	....	.....	10	10	10	.....	1.08
.775	.488	.712	.658	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.712	.653	.712	.692	.....	.....	.....	....	....	....	....	.....	10	10	9	.....	.....
.788	.807	.811	.802	.....	.....	.....	....	....	....	....	.....	5	10	10	.....	.04
.761	.525	.568	.618	.....	.....	.....	....	....	....	....	.....	10	10	0	.....	.....
.718	.457	.596	.590	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.601	.455	.533	.530	.....	.....	.....	....	....	....	....	.....	3.5	4.3	3.1	.....	1.53
.556	.556	.644	.585	.....	.....	.....	....	....	....	....	.....	9	10	8	.....	.....
.449	.496	.529	.491	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.510	.281	.431	.407	.....	.....	.....	....	....	....	....	.....	10	1	0	.....	.....
.371	.323	.746	.480	.....	.....	.....	....	....	....	....	.....	3	10	10	.....	.01
.584	.543	.685	.604	.....	.....	.....	....	....	....	....	.....	10	10	10	.....	.01
.645	.281	.392	.439	.....	.....	.....	....	....	....	....	.....	1	0	0	.....	.....
.308	.164	.255	.242	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.520	.184	.509	.404	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.556	.392	.712	.553	.....	.....	.....	....	....	....	....	.....	8	8	10	.....	.....
.449	.761	.761	.657	.....	.....	.....	....	....	....	....	.....	10	10	10	.....	.....
.890	.768	.655	.771	.....	.....	.....	....	....	....	....	.....	10	10	10	.....	.60
.431	.570	.721	.574	.....	.....	.....	....	....	....	....	.....	10	9	2	.....	.....
.584	.610	.622	.605	.....	.....	.....	....	....	....	....	.....	10	9	10	.....	.....
.746	.515	.467	.576	.....	.....	.....	....	....	....	....	.....	10	10	10	.....	.....
.659	.644	.622	.642	.....	.....	.....	....	....	....	....	.....	8	10	10	.....	.....
.754	.628	.712	.698	.....	.....	.....	....	....	....	....	.....	10	10	10	.....	.....
.582	.556	.622	.587	.....	.....	.....	....	....	....	....	.....	10	5	10	.....	.....
.525	.529	.659	.571	.....	.....	.....	....	....	....	....	.....	10	0	10	.....	.....
.730	.480	.788	.664	.....	.....	.....	....	....	....	....	.....	10	10	10	.....	.05
.685	.556	.541	.594	.....	.....	.....	....	....	....	....	.....	10	0	0	.....	.....
.800	.792	.907	.833	.....	.....	.....	....	....	....	....	.....	10	10	10	.....	.60
.893	.543	.570	.669	.....	.....	.....	....	....	....	....	.....	10	8	10	.....	.....
.740	.509	.556	.602	.....	.....	.....	....	....	....	....	.....	0	10	10	.....	.....
.594	.476	.802	.624	.....	.....	.....	....	....	....	....	.....	10	5	0	.....	.....
.829	.853	.550	.744	.....	.....	.....	....	....	....	....	.....	10	10	0	.....	.24
.622	.800	.811	.744	.....	.....	.....	....	....	....	....	.....	0	9	10	.....	.....
.719	.463	.492	.558	.....	.....	.....	....	....	....	....	.....	10	2	10	.....	.....
.623	.337	.509	.490	.....	.....	.....	....	....	....	....	.....	9	0	0	.....	.....
.377	.392	.635	.435	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.553	.412	.635	.533	.....	.....	.....	....	....	....	....	.....	0	0	0	.....	.....
.845	.398	.712	.652	.....	.....	.....	....	....	....	....	.....	0	0	10	.....	.....
.618	.510	.621	.583	.....	.....	.....	....	....	....	....	.....	6.7	5.7	6.1	.....	1.51

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.				Dry bulb, or temperature of the open air.						Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°		°	°	°	°	°	°				
Jan. 1	29.655	29.605	.....	29.630	11	14	....		14	17	....	15.5	....	.....	.037	.048	....	.043
2	29.608	29.357	29.376	29.447	10	18	14.5		12	21	17	16.7	....	11.5	.017	.065	.061	.048
3	29.338	29.219	29.305	29.287	11	22	23		13	24	25.5	20.8	....	10	.049	.095	.095	.080
4	29.341	29.343	29.312	29.332	27	30	28.5		29	32	30	30.3	....	20.5	.124	.144	.139	.136
5	28.931	28.882	28.668	28.894	27	31	26		29	33	28.5	30.2	....	24.5	.124	.151	.112	.129
6	29.094	29.201	29.284	29.193	22	21	10		24.5	23	13	20.2	....	12	.089	.091	.034	.071
7	29.039	29.048	.....	29.044	5	11	....		8	13	....	10.5	....	.....	.021	.049	....	.035
8	28.985	29.055	29.112	29.051	8	17	10		10	20	13	14.3	....	8	.040	.060	.034	.045
9	29.111	29.135	29.197	29.148	9.5	16.5	8		12	19	10.5	13.8	....	8.5	.038	.063	.034	.045
10	.....	.....	.....	.....	....	....	....		....	....	....	....	....	....	....	....	....	....
11	29.206	29.366	29.473	29.348	6	18	10		8	20	13	13.7	....	5	.034	.076	.034	.048
12	29.627	.....	29.610	29.619	15	....	17.5		11.5	....	20	18.8	....	8.5	.057	....	.068	.063
13	29.363	29.206	29.265	29.278	20	22.5	20.5		22	24	22	22.7	....	17	.085	.103	.093	.094
14	29.457	29.418	29.362	29.412	19	20	18		21	22	20	21.0	....	19	.080	.085	.076	.080
15	29.524	29.567	29.453	29.515	14	19	17		16	21	19	18.7	....	13	.059	.089	.071	.070
16	29.313	29.220	29.180	29.238	16.5	21	19		18.5	23	21	20.8	....	15.5	.069	.090	.080	.080
17	29.331	29.610	29.701	29.547	19	14	13		21	16	15	17.3	....	9	.080	.059	.056	.065
18	29.824	29.773	29.723	29.773	6	12	3		9	15	5.5	09.8	....	4	.023	.041	.022	.029
19	29.593	.....	29.316	29.454	− 7	....	− 2		− 5	....	0	−02.3	....	− 8	.009	....	.017	.013
20	29.195	29.077	29.077	29.116	− 8	11.5	19		− 6	13.5	21	09.3	....	− 9	.007	.050	.080	.046
21	28.997	29.074	29.134	29.068	19	15.5	22		21	17	24	20.7	....	17	.080	.071	.095	.082
22	29.372	29.350	29.475	29.399	19	20	17		21	22	20	21.0	....	10	.080	.085	.060	.075
23	29.520	.....	29.723	29.622	14	....	17		16	....	20	18.0	....	15	.059	.....	.060	.060
24	29.835	29.862	29.717	29.805	20	26	25		22	28	27	25.7	....	20	.085	.117	.112	.105
25	29.456	29.072	28.687	29.072	24	24	26		26	26	28	26.7	....	25	.106	.106	.117	.130
26	28.892	28.925	.....	28.909	17	21	....		19	23	....	21.0	.....	.....	.071	.080	....	.089
27	29.247	29.269	29.435	29.317	15	22	17		18	24	20	20.7	....	15.5	.052	.095	.060	.069
28	29.492	29.363	29.356	29.404	14	16	13		17	18	16	17.0	....	14.5	.048	.067	.044	.053
29	29.530	29.545	29.792	29.622	1	6	0		3	9	3	05.0	....	0	.023	.023	.010	.019
30	29.717	29.644	29.551	29.637	−14	1	9		−12	3	12	01.0	....	−15	.....	.023	.031	.027
31	29.351	29.209	28.929	29.163	12	20	23		15	22	25	16.3	....	10	.041	.085	.100	.075
Means....	29.364	29.309	29.344	29.339	12.4	18.1	15.7		14.3	20.3	18.1	17.2	....	−15	.058	.078	.066	.066
Feb. 1	29.153	.....	29.332	29.243	29.5	....	22.5		32	....	25	28.5	....	25	.134	.....	.092	.113
2	.....	.....	28.794	28.794	.....	.....	26		.....	.....	28	28.0	....	27.5	.....	.....	.117	.117
3	28.771	28.721	28.879	28.790	22.5	26.5	24		25	29.5	27.5	27.3	....	22	.092	.109	.089	.097
4	28.929	28.932	.....	28.930	14.5	23.5	....		17.5	26	....	14.5	.....	.....	.044	.097	.....	.070
5	29.147	29.182	29.238	29.189	26	28	29.5		28.5	31	32	30.5	....	22	.112	.119	.134	.122
6	29.266	29.418	29.432	29.372	21	30	29.5		23	32	32	29.0	....	21	.090	.144	.134	.123
7	29.376	29.391	29.374	29.380	22	34	33.5		24.5	37	36	32.5	....	26	.089	.157	.159	.135
8	29.246	29.150	29.068	29.121	27.5	33.5	36		30	36	38.5	34.8	....	28.5	.121	.159	.179	.153
9	29.095	29.064	29.298	29.152	25.5	20	7		28	22	9.5	19.8	....	9.5	.109	.085	.031	.075
10	29.598	29.808	29.817	29.774	1	1.7	14		3	20	16.5	13.2	....	0	.023	.060	.054	.046
11	29.611	29.458	29.522	29.530	9	21.5	33		11.5	23.5	35	23.3	....	8.5	.037	.092	.162	.097
12	29.531	29.490	29.442	29.488	33.5	24	35.5		25	36	37	32.7	....	31	.172	.170	.188	.177
13	29.234	29.014	29.128	29.159	33	37	42		35	39	43.5	39.2	....	35	.162	.194	.247	.201
14	29.656	29.660	29.792	29.703	30	27	19.5		32	29	22	27.7	....	22	.144	.124	.079	.115
15	29.601	29.543	29.240	29.461	20	27	30		22	29	31	27.3	....	15.5	.085	.124	.155	.121
16	28.847	28.854	29.063	28.921	35.5	32	29.5		38	35	32	35.0	....	29.5	.175	.142	.134	.150
17	29.358	29.376	29.367	29.367	26.5	30	33.5		29.5	33	35.5	32.7	....	27	.109	.132	.166	.136
18	29.178	29.124	29.376	29.226	28	34	32		30	36	35	37.0	....	27	.130	.170	.142	.147
19	29.555	29.517	.....	29.536	20	21	....		22.5	23	....	22.8	.....	.....	.079	.090	.....	.085
20	29.315	29.338	.....	29.327	21	20	....		23.5	22	....	22.8	.....	.....	.084	.085	.....	.085
21	.....	29.194	29.345	29.269	....	28	28		....	30	30	30.0	....	21	.....	.130	.130	.130
22	29.583	29.530	29.333	29.482	19	15	22		21	17	24	20.7	....	18.5	.080	.063	.095	.079
23	.....	.....	.....	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
24	29.217	29.205	29.192	29.205	32.5	34.5	28		35	38	30	34.3	....	27.5	.152	.154	.130	.145
25	29.413	29.393	29.363	29.393	23	26	25.5		25	29	28	27.3	....	23	.100	.106	.109	.105
26	29.471	29.577	29.544	29.531	22	32	27		24	36	30	30.0	....	20	.095	.129	.113	.112
27	.....	29.610	29.915	29.553	....	36	31		....	39	34	36.5	....	19.5	.....	.173	.139	.104
28	.....	29.276	29.263	29.269	....	34	35		....	36.5	37.5	37.0	....	32	.....	.163	.171	.167
Means....	29.311	29.313	29.321	29.312	23.6	28.0	28.0		25.4	30.7	30.4	27.6	....	0	.062	.126	.131	.119

the northern and northwestern lakes at Tawas City, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.457	.509	.....	.483	SW...	SW...	.....	4	8	....	4.0	S. 45 W.	1	8	....	.....	.....
.206	.570	.665	.480	SW...	SW...	SW...	8	18	5	10.3	S. 45 W.	8	5	8	.....	.....
.623	.738	.689	.683	SW...	SW...	SW...	2	8	12	7.3	S. 45 W.	5	8	10	.....	.....
.775	.794	.836	.802	SW...	S....	SE....	2	3	2	1.9	South ..	8	10	10	.....	.....
.775	.800	.716	.764	SE....	SW...	SW...	2	2	2	1.7	S. 13 W.	10	10	10	.....	.....
.680	.730	.438	.616	NW...	NW...	NW...	5	10	5	6.7	N. 45 W.	10	8	0	.....	.08
.334	.623	.....	.479	W	W	.....	3	4	....	2.3	West...	0	5	....	.....	.....
.582	.556	.438	.525	NW ..	NE...	NW...	3	4	6	3.3	N. 22 W.	0	8	0	.....	.....
.513	.616	.488	.539	NW...	NW...	NW...	8	12	17	12.3	N. 45 W.	5	0	0	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.553	.702	.438	.564	NW...	NW..	NW...	2	3	2	2.3	N. 45 E.	4	5	0	.....	.....
.597	.....	.629	.613	NW...	.....	NW...	6	....	15	7.0	N. 45 W.	9	....	.....	.....	.....
.721	.803	.790	.771	SE....	SE....	NE...	20	10	4	10.0	S. 53 E.	10	10	10	.....	.....
.712	.721	.702	.712	NW...	NW..	NW...	4	4	2	3.3	N. 45 W.	10	10	10	.....	.16
.639	.712	.692	.688	NW...	NE...	S.....	4	2	15	3.7	S. 8 W	10	10	10	.....	.30
.687	.730	.712	.710	NW...	NW..	NW...	2	2	2	2.0	N. 45 W.	10	10	10	.....	.06
.712	.659	.648	.673	NW...	NW...	N.....	15	15	12	13.3	N. 32 W.	10	10	10	.....	.04
.356	.475	.388	.406	NW...	N.....	W	10	8	1	5.7	N. 27 W.	9	2	0	.....	.....
.257	.....	.393	.325	W....	.....	W	2	....	2	1.3	West...	0	....	0	.....	.....
.225	.629	.712	.522	W....	NW...	NE...	2	8	15	5.7	N. 9 E..	10	10	10	.....	.....
.712	.752	.738	.734	NW...	NW...	NW...	10	17	10	12.3	N. 45 W.	10	10	10	.....	.22
.712	.721	.556	.663	NW...	NW...	N.....	6	10	3	6.0	N. 39 W.	5	10	10	.....	.24
.659	.....	.556	.608	NW...	.....	W	3	....	3	2.0	N. 70 W.	5	....	0	.....	.....
.721	.768	.761	.750	SW...	SW...	SW...	8	8	5	7.0	S. 45 W.	10	10	10	.....	.....
.754	.754	.768	.759	NE...	NE...	SW...	20	35	15	13.3	N. 45 E.	10	10	10	.....	.....
.692	.730	.....	.711	SW...	NW...	.....	10	15	....	6.0	N. 79 W.	10	10	....	.....	.72
.525	.738	.556	.606	NW...	NW...	NW...	3	16	2	7.0	N. 45 W.	0	10	....	.....	.....
.509	.682	.492	.561	W....	W	W	2	15	10	9.0	West...	10	10	....	.....	.....
.460	.356	.193	.336	W....	W	W	2	18	2	7.3	West...	0	6	0	.....	.....
.....	.460	.448	.439	W....	S.....	SW...	2	18	20	12.0	S. 27 W.	0	9	10	.....	.....
.475	.721	.746	.647	S.....	S.....	S.....	4	10	16	6.7	South ..	10	10	10	.....	.....
.574	.668	.598	.605	.....	.....	.....	....	....	....	3.0	N. 75 W.	6.6	7.2	6.6	.....	1.82
.744	.....	.684	.714	SW...	.....	SW...	6	....	5	3.7	S. 45 W.	6	....	5	.....	.....
.....	.....	.768	.768	.....	.....	N.....	.....	.....	15	5.0	North ..	.....	.....	10	.....	.....
.684	.670	.593	.649	NW...	NW...	W	3	4	2	2.7	N. 53 W.	5	...	0	.....	.....
.448	.694	.....	.571	W....	NE....	.....	2	8	....	2.3	N. 32 E	0	10	....	.....	.....
.716	.685	.744	.715	SW...	SW...	SW...	6	5	4	5.0	S. 45 W.	10	3	10	.....	.....
.730	.794	.744	.756	NE...	S.....	SW...	5	4	4	1.3	S. 10 E	5	10	10	.....	.....
.680	.712	.753	.715	W....	S.....	SW...	2	8	11	6.0	S. 33 W.	0	8	9	.....	.....
.729	.753	.768	.750	W....	S.....	S.....	2	5	2	2.7	S. 15 W.	5	10	10	.....	.....
.713	.721	.470	.635	NW...	NW...	NW...	5	6	11	7.3	N. 45 W.	8	10	0	.....	.....
.460	.556	.582	.533	W....	S.....	W	2	10	2	3.3	South ..	0	3	0	.....	.....
.505	.734	.797	.679	SW...	SW...	SW...	10	15	3	9.3	S. 45 W.	0	10	10	.....	.....
.847	.802	.854	.834	SW...	SW...	S.....	4	10	3	5.3	S. 38 W.	10	10	10	.....	.....
.797	.816	.875	.829	NE...	S.....	SW...	6	8	4	2.3	S. 12 E.	10	10	10	.....	.....
.794	.775	.652	.740	NW...	NW...	SW...	3	8	3	3.7	N. 59 W.	10	10	8	.....	.....
.721	.775	.893	.796	NE...	NE...	NE...	10	12	11	11.0	N. 45 E	8	10	10	.....	.....
.765	.698	.744	.736	SW...	SW...	SW...	16	30	14	20.0	S. 45 W.	2	10	8	.....	.50
.670	.703	.799	.724	SW...	SW...	SW...	8	8	3	6.3	S. 45 W.	5	0	10	.....	.....
.782	.802	.698	.761	SW...	NE...	N.....	5	4	10	3.0	N. 5 W.	8	10	10	.....	.....
.658	.730	.....	.694	NW...	NE...	.....	5	12	....	4.3	N. 18 E	8	10	....	.....	.....
.669	.721	.....	.695	W....	NE....	.....	2	8	....	2.3	N. 32 E.	3	9	....	.....	.....
.....	.782	.782	.782	.....	NE...	N.....	...	4	2	1.7	N. 29 E	....	10	10	.....	.....
.712	.761	.738	.737	NW...	NE...	NE...	2	11	13	8.0	N. 40 E	5	10	10	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.747	.673	.782	.734	NW...	NW...	SW...	11	3	5	5.0	N. 63 W.	4	10	10	.....	.....
.746	.665	.711	.707	W....	SE....	SE....	3	3	8	3.0	S. 32 E.	0	0	10	.....	.....
.738	.610	.675	.674	NW...	NW...	SW...	2	4	2	2.0	N. 62 W.	3	2	3	.....	.....
.....	.726	.712	.719	.....	S.....	SW...	....	2	6	2.7	S. 32 W.	....	9	5	.....	.....
.....	.756	.762	.759	....	E.....	E.....	....	2	2	1.3	East....	....	8	10	.....	.....
.698	.724	.732	.719	.....	.....	.....	....	....	....	1.4	S. 73 W.	5.0	8.0	8.0	.....	.50

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.				Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°		°	°	°	°	°	°				
March 1	29.042	28.771	28.687	28.833	33	37	42.5		35	38	44	39.0	....	32.5	.162	.207	.252	.207
2	29.122	29.301	29.274	29.232	19	18	17		22	20	20	20.7	....	16	.069	.076	.060	.068
3	29.398	29.237	29.112	29.249	7	19	20		10	21	22	17.7	....	5.5	.026	.080	.085	.064
4	29.200	29.284	29.372	29.279	19	23	24		20	25	26	23.7	....	17	.092	.100	.106	.099
5	29.530	29.556	.....	29.543	16.5	25	....		19	29	....	24.0	....	...	.063	.089	....	.076
6	29.741	29.610	29.459	29.603	10.5	23	23		12.5	25	25	20.8	....	9	.047	.100	.100	.082
7	29.330	29.426	29.629	29.462	25	30	27		26.5	32.5	30	29.7	....	22.5	.118	.138	.113	.123
8	29.675	.....	.....	29.675	16	....	....		18.5	....	....	18.5	....	....	.161	....	....	.161
9	29.562	29.456	29.423	29.480	25	34	29		27.5	38	32	32.5	....	15	.106	.144	.136	.125
10	29.057	28.843	28.861	28.920	31	33.5	28		32.5	34.5	39.5	35.5	....	30	.157	.179	.210	.182
11	29.376	29.482	.....	29.429	30	32.5	....		32	35	....	22.3	....	....	.144	.152	....	.148
12	29.366	29.267	29.355	29.329	21	26	27		23.5	29	29	27.2	....	21	.084	.106	.124	.105
13	29.156	29.155	29.293	29.201	25	23	15		26.5	26	18	23.5	....	16	.118	.089	.052	.086
14	29.491	.....	29.567	29.529	2.5	....	15		5	....	17	07.3	....	3	.020	....	.063	.042
15	29.663	29.597	29.630	29.627	6	11	14		8.5	13	16	12.5	....	5.5	.029	.049	.059	.046
16	29.506	29.291	19 158	20.318	20.5	29.5	26		23	32	27	27.3	....	7	.061	.134	.129	.115
17	29.024	29.068	29.297	29.130	21.5	24.5	16		24	27	18	23.0	....	18	.086	.103	.067	.085
18	29.322	29.315	.....	29.319	7	23	....		10	25	....	17.5	....	....	.126	.100	....	.063
19	29.503	.....	29.583	29.543	13	....	30		16	....	32	24.0	....	15	.044	....	.144	.094
20	29.698	29.672	29.659	29.676	19	41	27		22	45	30	32.3	....	25	.069	.205	.113	.129
21	29.451	29.225	29.277	29.351	26	32	33		28.5	34	35	32.5	....	26	.112	.155	.162	.143
22	29.350	.....	29.275	29.313	33	....	35		34	....	36	35.0	....	30	.175	....	.191	.183
23	39.455	29.447	29.438	29.447	32	34	31		34	36	33	34.3	....	25.5	.155	.170	.151	.159
24	29.335	29.237	29.297	29.290	32	33	33		34	35	35	34.7	....	30.5	.155	.169	.162	.160
25	29.446	29.585	29.658	29.563	23	26	27		25	29	29.5	27.8	....	23	.100	.106	.118	.108
26	29.612	29.515	29.295	29.471	18	26	23.5		20	29	25.5	24.8	....	18.5	.076	.106	.103	.095
27	29.165	29.177	29.229	29.190	27	29	26.5		29.5	32	29	30.2	....	25	.118	.126	.115	.130
28	29.337	29.294	29.335	29.322	20	28	27		22.5	32	30	28.2	....	21	.079	.108	.113	.100
29	29.270	29.209	.....	29.240	20	36	....		22.5	40	....	31.3	....	....	.079	.160	....	.120
30	.....	29.032	29.099	29.066	....	40	31		....	46	34	40.0	....	30	....	.169	.139	.154
31	.....	28.975	.....	28.975	....	40	....		....	42	....	42.0	....	....	....	.221	....	.221
Means....	29.386	29.300	29.329	29.378	20.6	28.8	26.3		22.9	31.6	28.1	27.1	....	3	.095	.131	.122	.118
April 1	28.736	28.786	28.906	28.809	37.5	40	46		38.5	43	42	41.2	....	21	.211	.208	.221	.213
2	29.184	29.278	.....	29.231	30	28	....		32.5	42	....	37.3	....	....	.138	....	....	.138
3	29.456	.....	.....	29.456	26	....	....		28	....	....	28.0	....	....	.117	....	....	.117
4	28.999	29.045	28.957	29.000	28.5	37	35.5		30	39	37	35.3	....	30	.139	.194	.188	.174
5	28.877	28.964	29.100	28.980	35	31	29		37	33	31	33.7	....	30	.178	.151	.137	.153
6	29.127	28.954	28.981	29.021	23	36	40		25	40	42	35.7	....	24	.104	.160	.221	.162
7	29.126	29.203	29.293	29.207	35	38	39		38	42	41	40.3	....	35	.165	.177	.212	.185
8	29.232	29.350	29.515	29.366	30	43	34		32	45	36	37.7	....	32.5	.144	.251	.170	.188
9	29.569	29.422	29.338	29.443	28.5	38	39.5		31	40	42	37.7	....	28	.128	.203	.210	.180
10	29.291	29.176	29.151	29.206	24.5	35.5	40		27	38	42	35.7	....	25.5	.086	.175	.221	.161
11	29.136	.....	.....	29.136	32.5	....	....		35	....	....	35.0	....	....	.152	....	....	.152
12	29.230	29.350	29.287	29.289	30	45	42		32	49	44	41.7	....	30	.144	.247	.241	.211
13	29.291	29.172	29.138	29.200	40	51	49		42	55	51	49.3	....	35.5	.221	.321	.321	.288
14	29.026	29.020	29.011	29.019	46	46	47		48	48	49	48.3	....	43	.284	.284	.297	.288
15	29.106	29.162	29.225	29.164	47	44	47		49	47.5	49	48.5	....	45	.277	.242	.297	.279
16	29.457	29.396	29.527	29.460	38	49	49		41	53	51	48.3	....	40	.190	.295	.321	.268
17	29.075	29.639	29.508	29.407	31	44	38		34	47	40	40.3	....	32	.139	.249	.203	.197
18	29.390	29.305	29.203	29.299	41	49	47		42.5	52.5	49	48.0	....	36	.238	.302	.297	.279
19	28.966	28.901	29.079	28.982	45	41	42		48	46	45.5	46.5	....	37	.280	.192	.221	.224
20	29.161	.....	.....	29.161	34	....	....		36	....	....	36.0	....	....	.170	....	....	.170
21	28.947	29.074	29.230	29.084	30	33	32.5		32	35	33	33.3	....	30	.144	.162	.178	.161
22	.....	29.420	.....	29.420	....	41	....		....	44	....	44.0	....	....	....	.216	....	.216
23	29.466	29.371	29.400	29.412	32	39	39		34	42	41	39.0	....	28.5	.159	.199	.212	.190
24	29.352	29.290	.....	29.321	32	46	....		35	50	....	42.5	....	....	.142	.258	....	.200
25	29.254	.....	.....	29.254	46	....	....		48	....	....	48.0	....	....	.284	....	....	.284
26	29.042	28.946	.....	28.994	43	52	....		47	55	....	51.0	....	....	.219	.349	....	.284
27	29.356	29.444	29.423	29.408	27	32	33		29	36	36	33.7	....	27	.124	.129	.149	.134
28	29.079	29.151	29.193	29.141	46	48	44		47	51	46	48.0	....	37.5	.297	.296	.292	.295
29	29.373	29.305	29.279	29.319	32	45	44		36	48.5	46.5	43.7	....	33	.129	.253	.255	.212
30	29.107	28.991	29.024	29.041	40	43	41		42	46.5	43	43.8	....	39	.221	.232	.231	.228
Means....	29.187	29.197	29.217	29.208	34.8	41.3	40.5		37.1	44.9	42.6	41.0	....	21	.145	.230	.230	.207

the northern and northwestern lakes at Tawas City, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.797	.905	.876	.859	S	SW ...	SW ...	12	4	75	29.3	S. 40 W	10	10	10	.....	.18
.584	.702	.556	.614	NW ...	NW ...	NW ...	11	10	10	10.6	N. 45 W	6	5	6	.....	.....
.377	.712	.721	.603	W	NE ...	NE ...	4	25	12	11.7	N. 40 E	0	10	10	.....	.....
.850	.746	.754	.783	NW ...	NW ...	NW ...	35	12	4	17.0	N. 45 W	10	10	10	.....	.....
.616	.556	.....	.586	NW ...	NW ...	.....	75	12	....	29.0	N. 45 W	3	1	....	.....	.08
.616	.746	.746	.703	NE ...	NE ...	NE ...	100	100	4	68.0	N. 45 E	8	10	0	.....	.....
.818	.748	.675	.747	NE ...	NE ...	NW ...	12	25	12	13.0	N. 27 E	10	5	0	.....	.....
.610	.....	.....	.610	NW ...	.....	.....	4	.....	....	1.3	N. 45 W	0	....	....	.....	.....
.707	.628	.694	.676	NW ...	S	NE ...	12	45	60	11.3	N. 80 E.	10	4	10	.....	.....
.848	.896	.863	.869	SE	NE ...	NW ...	35	45	12	17.0	N. 72 E	10	10	10	.....	.15
.794	.747	.....	.770	NW ...	N	.....	25	35	....	18.3	N. 19 W	7	9	....	.....	.....
.669	.665	.775	.703	N	N	N	25	45	35	35.0	North ..	8	7	8	.....	.....
.818	.634	.525	.659	NW ...	NW ...	NW ...	45	100	15	53.3	N. 45 W	10	8	0	.....	.....
.376	.....	.671	.524	NW ...	.....	N	25	....	35	18.3	N. 19 W	0	....	0	.....	.....
.452	.623	.659	.578	W	W	W	12	12	45	23.0	West ...	0	0	0	.....	.....
.663	.744	.880	.763	W	SW ...	NE ...	12	25	20	5.3	S. 77 W	0	5	10	.....	.....
.674	.703	.682	.686	NW ...	NW ...	NW ...	25	25	12	20.7	N. 45 W	3	8	1	.....	.....
.377	.746	.....	.562	W	NW ...	.....	12	45	....	18.0	N. 54 W	0	9	....	.....	.....
.492	.....	.794	.643	NW ...	.....	SE	12	....	45	11.0	S. 45 E.	0	....	0	.....	.....
.584	.684	.675	.648	SW ...	NE ...	NW ...	35	10	35	14.3	N. 80 W	0	....	0	.....	.....
.716	.792	.797	.768	N	NE ...	E	75	4	10	26.0	N. 9 E..	0	10	10	.....	.....
.895	.....	.900	.898	NE ...	.....	NE ...	25	....	12	12.3	N. 45 E	10	....	10	.....	.22
.792	.802	.800	.798	S	S	N	4	2	25	6.3	North ..	10	10	10	.....	.15
.792	.797	.797	.795	SE	NE ...	N	35	4	25	9.3	N. 82 E	10	10	10	.....	.....
.746	.665	.725	.712	NW ...	NW ...	NW ...	45	75	4	41.3	N. 45 W	10	4	0	.....	.26
.702	.665	.750	.706	NW ...	NW ...	NE ...	4	35	15	14.0	N. 23 W	0	8	10	.....	.17
.725	.694	.720	.713	NE ...	NE ...	NE ...	16	25	25	22.0	N. 45 E.	10	10	5	.....	.....
.658	.594	.675	.642	W	W	W	2	12	4	6.0	West ...	0	1	0	.....	.....
.658	.645	.....	.652	W	W	.....	15	15	....	10.0	West ...	6	6	....	.....	.....
.....	.543	.712	.628	.....	NW ...	NW ..	....	14	20	11.3	N. 45 W	....	1	0	.....	.....
.....	.829	.....	.829	.....	S	.....	....	10	....	3.3	South ..	....	5	....	.....	....
.669	.748	.737	.685	.....	.....	.....	....	....	....	12.0	N. 16 W	5.2	6.8	5.2	.....	1.21
.906	.750	.829	.828	NW ...	SW ...	S	5	10	5	4.7	S. 51 W	10	10	6	.....	.....
.748	.....	.....	.748	SW ...	SW ...	.....	6	18	....	7.7	S. 45 W	0	0	....	.....	.....
.768	.....	.....	.768	S	.....	.....	5	.....	....	1.7	South ..	10	....	....	.....	.....
.836	.816	.854	.835	NE ...	NE ...	NE ...	6	4	8	6.0	N. 45 E	10	10	10	.....	0.30
.807	.800	.788	.798	NW ...	NW ...	NW ...	10	10	3	7.7	N. 45 W	10	10	5	.....	.....
.746	.643	.829	.740	NW ...	S	N	6	30	5	7.0	S. 12 W	0	0	0	.....	0.55
.719	.661	.824	.735	SW ...	S	NE ...	5	12	3	4.7	S. 5 W	10	5	0	.....	.....
.794	.840	.802	.812	SW ...	S	W	3	8	3	4.0	S. 25 W	8	10	5	.....	.....
.736	.820	.786	.781	SW ...	SW ...	NW ...	2	2	12	4.3	N. 64 W	0	5	3	.....	.....
.674	.765	.829	.756	N	S	SW ...	10	15	3	2.7	S. 15 W	0	....	....	.....	.....
.747	.....	.....	.747	W	.....	.....	2	.....	....	0.7	West ...	4	6	4	.....	.....
.794	.710	.836	.780	E	E	E	3	4	7	4.7	East	10	10	10	.....	.....
.829	.743	.859	.810	SW ...	S	S	2	3	4	3.0	S. 9 W.	10	10	10	.....	.....
.850	.850	.853	.851	S	S	S	2	4	2	2.7	South ..	10	8	0	.....	0.40
.853	.737	.853	.814	NE ...	NW ...	NE ...	10	12	2	5.7	North ..	0	0	0	.....	0.34
.738	.733	.859	.777	NW ..	W	NW ...	4	16	6	8.3	N. 73 W	6	10	10	.....	.....
.712	.772	.820	.768	E	E	NE ...	15	15	12	9.0	N. 72 E.	10	7	10	.....	.....
.873	.763	.853	.833	NE ...	SE	NW ...	2	4	2	0.9	East ...	3	8	10	.....	.....
.777	.617	.726	.707	W	W	NW ...	10	32	30	22.3	N. 71 W	4	....	....	.....	.....
.802	.....	.....	.802	S	.....	.....	3	.....	....	1.0	South ..	10	10	5	.....	.....
.794	.797	.946	.846	N	NE ...	NW ...	8	4	2	4.3	N. 6 E..	....	1	....	.....	.....
.....	.756	.....	.756	.....	E	.....	....	8	....	2.7	East	8	8	5	.....	.....
.792	.744	.824	.787	SW ...	S	S	10	8	13	9.7	S. 14 W	6	4	....	.....	.....
.698	.716	.....	.707	W	W	.....	2	10	...	4.0	West ...	0	....	....	.....	.....
.850	.....	.....	.850	SE	.....	.....	2	.....	....	0.7	S. 45 E.	9	10	....	.....	.....
.663	.805	.....	.724	S	SW ...	.....	25	35	....	18.3	S. 26 W	4	2	0	.....	.....
.775	.610	.705	.697	NW ...	E	SE	8	8	27	8.3	S. 58 E	10	10	10	.....	.....
.923	.790	.843	.852	NW ...	NE ...	SE	8	2	2	2.0	N. 28 W	0	1	10	.....	.....
.610	.743	.807	.720	SW ...	E	SE	18	8	12	7.3	S. 10 E	10	9	10	.....	.....
.829	.732	.833	.798	SE	SE	SE	4	2	2	2.6	S. 45 E	1	0	10	.....	.....
.781	.749	.825	.781	.....	.....	.....	....	....	....	7.8	S. 43 W	6.0	6.4	6.0	.....	1.59

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
					°	°	°	°	°	°	°						
1867.																	
May	29.139	29.167	29.278	29.195	35.5	42.5	35	37	44	36.5	39.2	....	26	.188	.252	.184	.218
1	.....	29.470	29.553	29.512	....	35	36	....	37	38	37.5	....	23	....	.178	.186	.182
2	29.635	29.572	29.452	29.553	30	33	31.5	33	36	34	34.3	....	28.5	.132	.149	.145	.142
3	29.154	29.096	19.031	29 094	39.5	43.5	49.5	41	45	51	45.7	....	30	.223	.263	.334	.273
4	29.016	29.031	29.163	29.070	44	48.5	49	46	51	51.5	49.5	....	43.5	.262	.308	.315	.295
5	29.128	29.155	.....	29.139	39	35	....	41	37	....	39.0	....	.....	.212	.178	....	.195
6	29.207	.....	.....	59.207	30	....	....	32.5	....	....	32.5	....	.....	.138	.....	.....	.138
7	26.235	29.141	29.094	29.157	32	47	46	35	51	48	44.7	....	33	.142	.270	.284	.232
89	29.079	.....	29.033	29.056	37	....	39	40	....	40.5	40.3	....	34	.181	....	.219	.200
10	29.139	29.113	29.153	29.135	37.5	48	47	39.5	50	49	46.2	....	34	.198	.309	.297	.268
11	29.280	29.282	.....	29.281	50	53	....	42	55.5	....	48.8	....	.....	.....	.....	.370	.370
12	26.444	29.411	29.340	29.398	35	48	47.5	38	51	50	46.3	....	33	.165	.296	.296	.252
13	29.134	29.003	28.984	29.040	43	44	43	44.5	46	45	45.2	....	42	.258	.262	.251	.257
14	28.999	28.933	28.981	28.971	42.5	45	45	44	47	47	46.0	....	41	.252	.273	.273	.266
15	28.966	28.981	29.095	29.014	41.5	46	43.5	43	48	45.5	45.5	....	40	.242	.284	.256	.261
16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	29.280	29.347	.....	29.314	40	49	....	42	52	....	47.0	....	.....	.221	.308	....	.265
18	29.085	29.520	29.435	29.347	36	46	48	38	49	50	45.7	....	34	.186	.271	.309	.255
19	20.383	29.339	29.282	29.335	42	48	48	44	50	51	48.3	....	39.5	.241	.309	.286	.278
20	29.264	29.255	.....	29.259	38	42.5	....	40	45	....	42.5	....	.....	.203	.239	.....	.221
21	29.064	.....	.....	29.064	47	.....	.....	48.5	.....	.....	48.5	....	.....	.308	.....	.....	.308
22	28.781	28.835	28.883	28.833	42	44	40	43.5	45	42	43.5	....	40	.247	.275	.221	.248
23	28.944	29.026	29.141	29.037	38.5	46	44.5	40	48	47	45.0	....	38	.214	.284	.260	.253
24	29.136	29.086	.....	29.111	33	50	....	35	53	....	44.0	....	.....	.162	.321	.....	.242
25	28.951	28.868	28.917	28.912	49.5	49	50	51	51.5	52	51.5	....	33.5	.329	.315	.334	.326
26	29.148	.....	29.325	29.237	40	....	47.5	42	....	50	46.0	....	40.5	.221	.....	.296	.258
27	29.440	29.416	.....	29.428	40	46	....	42	48	....	45.0	....	.....	.221	.284	.....	.252
28	29.285	.....	29.218	29.252	43.5	....	45.5	45	....	47	46.0	....	35	.262	.....	.280	.271
29	.....	29.213	29.263	29.238	....	55	51.5	....	56.5	53	54.8	....	45	....	.413	.361	.387
30	29.289	29.276	29.399	29.321	47	55	54.5	49	59	56	54.7	....	46	.297	.380	.405	.361
31	29.514	29.487	.....	29.500	45	52	....	47	55	....	51.0	....	.....	.273	.349	.....	.311
Means....	29.182	29.201	29.192	29.200	39.9	46.0	44.8	41.6	48.4	46.9	45.1	....	23	.213	.282	.280	.260
June 1	29.321	29.253	29.092	29.222	48	55	54	50	58	56	54.7	....	43	.309	.393	.391	.364
2	28.850	28.775	28.705	28.777	56	60.5	60	58	62.5	62	60.8	....	52	.422	.458	.491	.457
3	28.801	28.925	29.056	28.927	54.5	59	60	56	62.5	62	60.2	....	55	.404	.453	.491	.449
4	29.161	294236	29.204	29.200	53	58.5	56	56	61.5	58	58.5	....	52	.363	.451	.422	.412
5	29.326	29.299	29.176	29.267	50	57.5	64	52	61	66	59.7	——	44	.334	.426	.569	.443
6	29.161	29.050	29.141	29.117	61	66	65.5	64	71.5	69	68.2	....	64	.497	.566	.581	.548
7	29.291	29.246	29.254	20.264	63	67	58.5	65	72	61	66.0	....	56.5	.549	.565	.458	.534
8	29.326	29.343	29.434	29.368	56	64	58	58.5	69	62	63.2	....	56	.416	.529	.429	.458
9	29.455	29.464	.....	29.459	63	61	....	65.5	69	....	64.3	....	.....	.542	.510	....	.526
10	29.418	29.373	29.325	29.372	53	64.5	63	55	67	65	62.3	....	51.5	.376	.573	.549	.499
11	.....	29.398	29.348	29.373	....	59	55	....	62	57	59.5	....	53	....	.469	.407	.438
12	29.264	29.226	29.338	20.276	62	65.5	60	65	69	63	65.7	....	63	.516	.581	.478	.525
13	28.885	.....	.....	28.885	63	.....	.....	65	.....	.....	65.0	....	.....	.549	.....	.....	.549
14	29.250	20.293	29.240	29.263	67.5	67	64	69.5	74.5	68.5	70.8	....	52.5	.645	.561	.536	.581
15	29.143	29.142	29.228	29.171	63	67.5	69	60	71	72	67.7	....	62	....	.636	.668	.647
16	29.333	29.298	29.362	29.331	57	62	60	64	66	62	64.0	....	57	.373	.502	.491	.455
17	29.393	29.298	29.378	29.356	58	10	74	61	63	76	66.7	....	55	.443	.478	.812	.578
18	29.295	29.400	.....	29.333	65	71.5	....	68	74	....	71.0	....	.....	.577	.737	....	.657
19	29.223	29.145	29.155	29.174	62	69.5	65	64.5	73.5	71	69.7	....	63	.522	.667	.537	.575
20	29.158	.....	29.151	29.155	63	....	65	65.5	....	68	66.5	....	61.5	.549	....	.595	.572
21	29.215	29.195	29.188	29.199	62	69	69	65	73	72	70.0	....	65	.516	.655	.668	.613
22	29.268	29.118	.....	29.193	60	67	....	63	71.5	....	67.3	....	.....	.478	.601	....	.540
23	29.313	29.361	29.498	29.391	63	60	56	66	66	61	64.3	....	55	.536	.438	.383	.452
24	29.506	29.428	29.374	20.436	64	57.5	59	68.5	60	63	63.8	....	57	.536	.432	.447	.472
25	29.506	29.510	.....	29.508	57	58.5	....	59	62	....	60.5	....	.....	.439	.444	....	.442
26	.....	26.464	29.411	29.438	....	62	62	....	67	64	65.5	....	55	....	.489	.529	.509
27	.....	23.383	29.191	29.287	....	68	65	....	74	68	71.0	....	62.5	....	.604	.577	.590
28	29.298	29.434	29.451	29.394	62	61	65	64	68	67	66.3	....	49	.529	.443	.591	.521
29	29.423	29.235	29.254	29.304	57.5	66	64	60	72	66	66.0	....	53	.440	.559	.569	.523
30	29.032	29.081	29.225	29.113	68	73	68	72	83	75	76.7	....	68	.631	.677	.591	.633
Means....	29.245	29.263	29.247	29.252	59.7	63.5	62.4	62.2	67.8	65.4	65.2	....	43	.480	.532	.530	.519

the northern and northwestern lakes at Tawas, Michigan.

VAPOR.				WIND.							Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.854	.876	.853	.861	NW...	SE....	NW...	6	4	10	4.0	N. 45 W	2	10	0	.....	.....
.....	.807	.811	.809	.....	NW...	NW...	....	15	4	6.3	N. 45 W	....	6	0	.....	.....
.703	.705	.756	.721	S.....	S	SE	10	15	16	12.7	S. 17 E	5	5	8	.....	.....
.867	.879	.894	.880	SE....	SE....	SE	25	10	10	15.0	S. 45 E	10	10	10	.....	.....
.843	.824	.826	.831	SW...	SW...	SW ...	6	25	5	12.0	S. 45 W	8	8	3	.....	.....
.824	.807	.....	.816	W....	NE	.....	3	12	....	3.3	N. 33 E	10	10	....	.....	.....
.748	.....	.....	.748	NW...	.....	.....	8	....	....	2.7	N. 45 W	10	....	....	.....	0.14
.698	.722	.850	.757	NE....	NE	NW...	10	12	2	7.7	N. 40 E.	....	8	0	.....	.....
.732	.....	.866	.799	NW...	.....	NW...	5	....	2	2.3	N. 45 W	0	....	4	.....	.....
.818	.856	.853	.842	NW...	NE ...	NW...	2	5	3	2.3	North ..	7	5	0	.....	.....
.....	.....	.839	.839	W	E	.....	10	10	....	....	.....	0	3	....	.....	.....
.719	.790	.820	.776	SW ...	NE	W	5	4	10	3 3	S. 86 W	0	8	10	.....	.....
.878	.843	.840	.854	NE....	NE	NE	18	24	10	17.3	N. 45 E	10	10	10	.....	.....
.876	.847	.847	.857	NW...	W	NW...	4	5	2	3.3	N. 65 W	10	10	10	.....	.080
.874	.850	.841	.855	NW...	E.	W	6	8	2	1.7	N. 21 E.	10	6	1	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.829	.794	.....	.812	N	SE....	.....	5	5	....	1.3	N. 68 E.	5	8	....	.....	.....
.811	.781	.856	.816	NW...	SE....	W	7	7	3	1.0	West...	0	1	0	.....	.....
.836	.856	.790	.827	N	E	NE ...	4	6	10	5 7	N. 50 E	10	10	10	.....	.....
.820	.800	.....	.810	NE....	E	.....	4	8	....	3.7	N. 76 E.	0	9	....	.....	.....
.888	.....	.....	.888	E	.....	.....	15	....	....	5.0	East ..	10	....	....	.....	.....
.875	.920	.829	.875	NW...	NW...	NW...	20	20	25	21.3	N. 45 W	10	10	10	.....	0.94
.864	.859	.809	.841	NW...	E	W	8	10	2	2.0	N. 21 E.	10	10	3	.....	.....
.797	.798	.....	.798	NW...	S	.....	3	8	....	2.3	S. 18 W	9	8	....	.....	.....
.894	.826	.861	.860	S	S	SW ...	14	8	6	9.0	S. 9 W..	10	8	6	.....	0.17
.829	.....	.821	.825	W.....	.....	W	5	....	3	2.7	West...	3	0	....	.....	.....
.829	.850	.....	.829	SE....	E	.....	2	4	....	2.0	S. 74 E	10	10	....	.....	.....
.879	.....	.833	.856	SE	.....	SW ...	7	....	8	3.3	S. 5 E..	10	....	10	.....	.....
.....	.904	.898	.901	.....	W	W	....	6	4	3.3	West...	....	10	10	.....	.....
.853	.761	.903	.839	W.....	W	NW...	7	14	7	8.7	N. 80 W	3	2	0	.....	.....
.847	.805	.....	.826	SE....	SE	.....	2	5	....	2.3	S. 45 E	1	8	....	.....	.....
.829	.823	.881	.828	.....	.....	.....	....	....	....	3.4	N. 27 W	6.4	7.4	5.2	.....	20.5
.856	.816	.872	.848	SE....	SE....	NE ...	2	4	6	2.8	East ...	10	10	10	.....	.....
.876	.885	.884	.882	S	S	W	6	9	10	6.2	S. 35 W	....	9	10	.....	.....
.903	.802	.884	.863	W	W	W	15	18	2	11.7	West...	10	10	0	.....	.....
.809	.826	.876	.837	NW...	SE....	N.....	2	6	3	1.0	N. 78 E.	6	4	5	.....	1.31
.861	.822	.891	.858	SE....	SE....	SW ...	2	5	2	2.3	S. 30 E.	0	1	1	.....	.....
.833	.733	.820	.795	SW ...	SW...	SW ...	2	15	2	6 3	S. 45 W	9	8	1	.....	.....
.890	.758	.853	.834	SW ..	S	N.....	12	4	2	4.7	S. 39 W	9	5	9	.....	.....
.847	.417	.772	.689	N	NE ...	W	8	15	2	6.7	N. 26 E	2	1	0	.....	.....
.864	.886	.....	.875	NE ...	E	.....	10	12	....	7.0	N. 70 E	0	1	....	.....	.....
.869	.867	.890	.875	S	SE....	NW...	4	6	2	2.3	S. 22 E	0	0	1	.....	.....
.....	.828	.874	.851	.....	E	N.....	....	10	6	4.0	N. 60 E	....	1	1	.....	0.08
.836	.820	.831	.829	S	SW ...	W	8	13	3	7.0	S. 35 W	1	9	1	.....	0.14
.890	.....	.....	.890	S	.....	.....	8	....	....	2.7	South ..	10	....	....	.....	.....
.897	.657	.770	.775	S	W	N.....	7	8	2	3.3	S. 60 W	10	8	9	.....	.....
.....	.825	.852	.839	S	S	SW ...	2	10	2	4.7	S. 6 W	10	4	1	.....	.....
.625	.786	.884	.765	NE ...	NE ...	N.....	10	8	8	8.0	N. 58 E	10	3	5	.....	0.06
.825	.831	.906	.854	SW...	SE....	SW ...	4	6	8	4.3	S. 17 W	10	3	10	.....	.....
.843	.879	.....	.861	S	E	.....	2	3	....	1.3	S. 60 E.	1	5	....	.....	.....
.862	.808	.718	.793	S	E	NE ...	2	3	5	2.3	N. 78 E	5	1	4	.....	.....
.890	.....	.869	.880	SE....	.....	N.....	2	....	2	0.7	N. 73 E.	10	....	....	.....	.....
.836	.807	.852	.832	W	SE....	NW...	2	12	3	2.7	S. 33 E	....	9	5	.....	.....
.831	.780	.....	.806	SE....	SW ...	.....	4	2	....	1.7	S. 16 E	9	10	....	.....	.....
.838	.685	.713	.745	W	W	NW...	15	25	2	13.7	N. 88 W	3	8	0	.....	.....
.770	.850	.776	.799	W	S	W	14	18	8	9.7	S. 51 W	0	3	0	.....	.....
.878	.800	.....	.839	NE ...	E	.....	6	8	....	4.3	N 71 E.	10	9	....	.....	.....
.....	.740	.888	.814	.....	E	E	....	5	3	2.7	East ..	....	1	1	.....	0.60
.....	.720	.843	.782	.....	SW ...	SW ...	....	8	3	3.7	S. 45 W	....	5	10	.....	.....
.888	.647	.893	.809	NW...	SE....	E	3	15	13	7.7	S. 69 E	10	1	10	.....	.....
.851	.712	.891	.818	W	S	SW ...	4	30	20	16.0	S. 23 W.	0	1	3	.....	.....
.804	.600	.681	.695	SW...	S W...	SW ...	11	22	3	1.20	S. 45 W.	3	5	5	.....	.....
.845	.772	.839	.798	.....	.....	.....	....	....	....	.09	S. 79 W	5.9	4.8	4.2	.....	2.19

Reductions of the monthly meteorological register of the survey

te.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.		
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity. inches and imals.		
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.
1867.					o	o	o	o	o	o	o	o	o		
y 1	29.282	29.301	29.276	29.286	64	66	61	67.5	69	66	67.5	....	56	.549	.599
2	29.305	29.238	29.192	29.245	58	66	70	61	72	74	69.0	....	55	.443	.559
3	29.280	29.190	.....	29.235	63	71	....	67	75.5	....	71.3	....	.....	.522	.698
4	.....	.....	.....	.....	....	....	....	....	....	....	.....	....	.....	....	....
5	29.141	.....	.....	29.141	61	....	....	63	....	....	63.0	....	.....	.510	....
6	29.100	29.152	29.154	29.135	63	69	64	65	74	68	69.0	....	61	.549	.641
7	29.234	29.411	.....	29.323	60	59	....	65	65	....	65.0	....	.....	.451	.420
8	29.495	.....	.....	29.495	55	....	....	59	....	....	59.0	....	.....	.365	....
9	29.313	29.294	29.118	29.242	63	59	66	65	61	69	65.0	....	55	.549	.473
10	29.227	29.217	29.229	29.258	69.5	71	75	72	78	79	76.3	....	77	.687	.664
11	29.374	29.435	29.445	29.418	53	55	55	57	58.5	58	57.8	....	54.5	.350	.387
12	29.470	29.512	29.556	29.513	49	49	60	56.5	53	64	57.8	....	43	.275	.295
13	.....	.....	.....	.....	....	....	....	....	....	....	.....	....	.....	....	....
14	29.491	29.513	29.518	29.507	59	60	55	64	68	60	64.0	....	33.5	.433	.411
15	29.221	29.238	29.368	29.276	63	65.5	60	65	69.5	67.5	67.3	....	60	.549	.575
16	29.467	29.464	29.463	29.465	64.5	63	59	67.5	68.5	63.5	66.5	....	53.5	.566	.502
17	29.518	29.500	29.599	29.512	66	62.5	57.5	68	67.5	60	65.2	....	57	.612	.559
18	29.468	29.508	29.764	29.580	54	63	60	55.5	68	65	62.8	....	50	.398	.509
19	29.606	29.473	29.459	29.513	55.5	66	63	61.5	72	68	67.2	....	54	.361	.559
20	29.498	29.591	29.412	29.500	50	63	66	53.5	70	70	64.5	....	62	.315	.482
21	29.340	.....	29.238	29.289	59.5	....	68	63	....	72	67.5	....	55	.462	.....
22	29.205	29.178	29.285	29.223	62	73.5	70	64	78	77	73.0	....	60	.529	.764
23	29.234	29.192	29.210	29.212	60.5	74.5	75	62	79.5	79	73.5	....	58	.507	.772
24	29.260	29.217	29.194	29.224	63	77	72	67	82	81	76.7	....	67	.522	.860
25	29.180	29.121	29.148	29.150	69	68	66	71	72	71	71.3	....	70	.682	.631
26	29.235	.....	29.161	29.132	58	....	69	61	....	72	66.5	....	60	.443	.....
27	29.230	29.075	29.044	29.116	57	74	74.5	62	79	80	73.7	....	60	.399	.772
28	29.079	.....	29.082	29.080	74	....	73	79	....	77	78.0	....	61.5	.772	....
29	29.323	29.376	28.985	29.228	55	64	64	60	68	69	65.7	....	58.5	.367	.543
30	29.488	29.431	29.373	29.431	50	65	63	55	70	68	64.3	....	50	.295	.530
31	.....	29.180	29.303	29.242	....	61	63	....	65	66	65.5	....	61.5	....	.483
Means ...	29.324	29.324	29.340	29.312	59.9	65.2	64.3	63.5	70.1	71.4	67.4	....	33.5	.481	.571
August 1	29.100	29.068	.....	29.084	61	66	....	64	68	....	66.0	....	.....	.465	.615
2	29.183	29.235	29.296	29.238	59	64.5	58.5	61	67.5	62	63.5	....	56	.473	.56
3	29.408	.....	29.396	29.402	54	....	67	59	....	70	64.5	....	55	.351	....
4	29.411	29.461	29.438	29.437	65	74	62	68	79	71	72.7	....	60	.577	.72
5	29.421	29.377	29.368	29.389	64	74	72	67	77.5	75	73.2	....	65	.556	.72
6	29.403	29.398	29.345	29.382	63	74	71	65	78.5	76	73.2	....	64.5	.549	.77
7	29.359	29.285	29.355	29.333	66	74	72	68	79	76	74.3	....	69	.612	.78
8	29.284	29.248	.....	29.266	65	71	....	67	75	....	71.0	....	.....	.591	.72
9	.....	.....	.....	.....	....	....	....	....	....	....	.....	....	.....	....	....
10	.....	.....	.....	.....	....	....	....	....	....	....	.....	....	.....	....	....
11	.....	.....	.....	.....	....	....	....	....	....	....	.....	....	.....	....	....
12	.....	.....	.....	.....	....	....	....	....	....	....	.....	....	.....	....	....
13	29.536	29.323	29.336	29.398	60	65.5	69	64	70	71	68.3	....	62	.465	....
14	29.491	29.438	29.396	29.442	63	70	66.5	68	73.5	70	69.5	....	63	.549	....
15	29.383	29.285	29.385	29.351	59	70	69.5	60.5	76	73	69.8	....	56.5	.480	....
16	29.115	29.010	29.043	29.056	63	75	66.5	65	80	70	71.7	....	61.5	.543	....
17	29.085	.....	.....	29.085	70	....	....	74	....	....	74.0	....	.....	.671	....
18	29.296	29.278	29.329	29.301	58	62	60	61	65	63.5	63.2	....	55	.445	....
19	29.338	29.358	29.357	29.351	62	63	58.5	65	68	62	65.0	....	57	.51	....
20	29.376	29.405	29.401	29.394	66	61	52	67	63.5	54	61.5	....	50.5	.68	....
21	.....	29.603	29.178	29.391	....	71	73	....	75.5	77	76.3	....	57	....	....
22	.....	29.022	29.072	29.047	....	70	70	....	78	73	75.5	....	68	....	....
23	29.298	29.301	29.420	29.340	54	60	52.5	57	65	55	88.5	....	44	.3	....
24	29.466	29.433	29.404	29.434	50	54	53.5	53	57	56.5	55.5	....	52.5	.3	....
25	29.388	29.338	29.311	29.346	55.5	68	64.5	57.5	72	68	65.8	....	46	.4	....
26	.....	.....	29.132	29.132	....	....	72	....	....	75	75.0	....	60	....	....
27	29.040	29.077	29.163	29.093	64	66	60	67	70	65	67.3	....	55	....	....
28	29.198	29.203	29.378	29.260	61	64	51	63	67	54	61.3	....	50	....	....
29	.....	29.438	29.409	29.424	....	54.5	60	....	63	63	63.0	....	40.5	....	....
30	29.219	29.185	29.174	29.193	56	57.5	59	58	60	61	59.7	....	52	....	....
31	.....	.....	29.317	29.317	....	....	55	....	....	60	60 0	....	51.5	....	....
Means ...	29.309	29.294	29.308	29.292	58.1	66.5	63.4	67.6	70.3	66.7	70.0	....	40.5	....	....

northern and northwestern lakes at Tawas City, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation=1,000.				Direction. From whence.			Velocity, in miles per hour.			Resultant velocity, in miles per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 a. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.817	.846	.755	.806	NW..	NE...	NW..	2	35	2	11.7	N. 39 E	9	10	7	.....	.....
.825	.712	.810	.782	N.....	S.....	SW..	4	4	12	4.0	S. 45 W.	1	5	10	.....	.....
.790	.791	.....	.790	W....	S.....	.....	2	10	....	3.7	S. 11 W.	3	8	....	.....	.49
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.886	.....	.....	.886	NW..	.....	.....	2	.....	.....	0.7	N. 45 W.	10	.....	.....	.....	.....
.890	.764	.793	.816	NW..	W....	W....	15	17	12	13.7	N. 75 W.	10	3	5	.....	.89
.731	.680	.....	.706	W....	NE...	.....	13	13	....	3.3	N. 23 W	8	8	....	.....	.....
.756	.....	.....	.756	SW..	.....	.....	12	.....	.....	4.0	S. 45 W.	3	.....	.....	.....	.45
.890	.882	.846	.873	S.....	E.....	SW..	14	16	12	8.0	S. 19 E	10	10	3	.....	.36
.876	.693	.822	.797	W....	W....	W....	18	22	2	14.0	West...	5	6	3	.....	.12
.752	.788	.816	.785	N.....	E.....	NE...	22	28	25	20.0	N. 49 E.	10	3	....	.....	.....
.647	.733	.780	.720	NE...	E.....	NW..	4	10	12	4.0	N. 21 E.	0	0	5	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.727	.601	.708	.679	W....	SW..	SW..	12	2	4	5.7	S. 75 W.	0	0	3	.....	.....
.890	.797	.621	.769	S.....	NW..	NW..	16	14	2	4.0	S. 67 W.	10	6	1	.....	.06
.842	.721	.751	.771	NW..	E....	W....	2	10	2	2.3	N. 78 E	0	3	0	.....	.10
.895	.890	.851	.879	S.....	SE....	SE....	2	4	42	6.0	S. 41 E	1	1	3	.....	.....
.902	.743	.731	.792	NE...	NE...	NW..	2	10	4	4.3	N. 26 E.	4	9	8	.....	.....
.662	.712	.743	.706	E.....	NE...	W....	4	10	4	3.3	N. 45 E.	9	8	10	.....	.....
.767	.658	.799	.741	NW..	SE....	NE...	12	35	2	7.7	S. 50 E	0	0	0	.....	.....
.803	.....	.804	.804	SW..	.....	NW...	35	....	2	11.7	S. 49 W.	0	....	10	.....	.....
.888	.798	.689	.792	NW..	SW..	SW..	2	12	35	15.7	S. 48 W.	3	4	5	.....	.....
.912	.779	.822	.838	SW..	SW..	NW..	2	4	2	2.0	S. 62 W.	0	9	4	.....	.....
.790	.787	.627	.735	W....	W....	W....	4	10	4	6.0	West...	10	10	10	.....	.....
.899	.804	.754	.819	NW..	SW..	N.....	45	4	10	17.3	N. 41 W.	10	10	10	.....	.....
.825	.....	.852	.839	SW..	.....	SW..	45	....	12	19.0	S. 45 W.	0	....	10	.....	.....
.718	.779	.761	.753	SE....	SE....	SE....	12	10	45	22.3	S. 45 E	0	4	8	.....	.....
.779	.....	.817	.798	SW..	.....	SW..	16	....	12	9.3	S. 45 W.	9	....	8	.....	.....
.708	.793	.747	.749	NW..	E.....	NW..	20	45	10	10.7	N. 47 E	1	6	0	.....	.....
.681	.751	.743	.725	W....	S.....	W....	12	10	35	16.0	S. 78 W.	0	1	9	.....	.02
.....	.783	.838	.810	.....	S.....	S.....	....	15	10	8.7	South..	....	10	10	.....	.....
.805	.762	.771	.818	.....	.....	.....	.....	.....	.....	2.1	S. 57 W.	4.4	5.6	5.9	.....	2.49
.780	.895	.....	.838	SW..	S.....	.....	15	15	....	9.3	S. 23 W.	10	9	....	.....	.58
.882	.842	.800	.841	N.....	S.....	SE....	24	24	12	4.0	S. 45 E.	10	10	5	.....	.42
.703	.....	.848	.776	NW..	.....	N.....	45	....	12	18.0	N. 36 W.	4	....	5	.....	.....
.843	.779	.851	.824	S.....	E.....	SW..	9	10	8	5.0	S. 18 E.	9	2	10	.....	.....
.841	.840	.858	.846	W....	S.....	W....	5	10	2	4.0	S. 33 W.	10	6	10	.....	.83
.890	.799	.771	.820	E.....	S.....	NW..	2	8	2	2.0	S. 6 E.	1	2	1	.....	.....
.895	.779	.815	.830	W....	S.....	W....	2	45	2	15.3	S. 5 W.	0	2	5	.....	.....
.893	.812	.....	.853	S.....	S.....	.....	4	2	....	2.0	South..	5	9	....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.780	.774	.899	.818	SE....	S.....	N.....	12	45	4	16.7	S. 10 E	3	2	10	.....	1.52
.892	.832	.823	.848	NW..	NE...	SW..	12	45	12	11.7	N. 25 E.	8	8	3	.....	.....
.910	.727	.830	.822	NW..	E.....	SE....	2	45	2	15.0	East...	0	2	0	.....	.....
.890	.803	.823	.839	SW..	S.....	NW..	35	14	30	16.3	S. 69 W.	2	2	10	.....	.....
.810	.....	.....	.810	SW..	.....	.....	12	.....	.....	4.0	S. 45 W.	0	.....	.....	.....	.....
.825	.836	.805	.822	NW..	NW..	NW..	12	12	2	8.7	N. 45 W.	10	10	0	.....	.....
.836	.703	.800	.793	NW..	NW..	NW..	4	2	12	6.0	N. 45 W.	3	5	3	.....	.....
.946	.859	.867	.891	NW..	NW..	NW..	25	45	12	27.3	N. 45 W.	6	8	3	.....	.....
.....	.791	.817	.804	.....	SE....	SE....	....	10	6	5.3	S. 45 E	....	8	8	.....	.....
.....	.653	.854	.759	.....	SW..	SW..	....	10	8	4.3	S. 45 W.	....	8	3	.....	.....
.812	.731	.837	.793	W....	W....	W....	10	13	8	10.3	West...	0	0	0	.....	.....
.798	.812	.810	.807	W....	W....	W....	12	45	4	20.3	West...	8	3	3	.....	.....
.874	.804	.812	.832	SW..	SE....	W....	4	25	12	7.0	S. 8 E	1	1	5	.....	.....
.....	.....	.858	.858	.....	.....	S.....	.....	.....	45	15.0	South..	.....	.....	6	.....	.....
.841	.799	.731	.790	W....	W....	W....	12	18	2	10.7	West..	0	2	0	.....	.14
.886	.841	.802	.842	W....	E.....	NW..	45	12	25	17.7	N. 71 W.	5	4	1	.....	.....
.....	.544	.831	.688	.....	NW..	SW..	....	12	8	5.0	N. 79 W.	....	8	0	.....	.....
.876	.851	.882	.870	S.....	S.....	S.....	18	15	8	13.3	South..	10	10	10	.....	.....
.....	.....	.708	.708	.....	.....	NW..	.....	.....	12	4.0	N. 45 W.	.....	.....	0	.....	.....
.850	.785	.822	.816	.....	.....	.....	.....	.....	.....	5.4	S. 46 W.	4.8	5.3	3.8	.....	3.49

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Sept. 1	29.248	29.251	29.259	29.253	60	55.5	58	63	60	57	62.0	.....	54	.478	.302	.....	.390
2	29.352	29.343	29.281	29.325	35	57	59	37	60	61	52.7	.....	35.5	.178	.496	.473	.382
3	29.161	29.125	29.256	29.181	60	58	57	64	62	61	62.3	.....	58	.465	.429	.412	.435
4	29.352	29.316	29.271	29.313	47.5	61	65	49	66	67	60.7	.....	53	.309	.470	.591	.457
5	29.218	29.100	29.030	29.116	57	70	71	62	74	74	70.0	.....	54	.399	.679	.718	.599
6	29.272	29.386	29.429	29.362	53	58	54	56	62	58.5	58.8	.....	54	.363	.429	.358	.383
7	29.622	29.640	29.622	29.628	53.5	56.5	51.5	55	60	55	56.7	.....	54.5	.391	.410	.335	.379
8	29.576	.....	29.318	29.295	59	.....	66	63.5	.....	68	65.8	.....	59	.449	.....	.612	.530
9	29.194	29.216	29.344	29.251	61	67	54	63	70	59	64.0	.....	56	.510	.622	.351	.494
10	29.437	29.436	29.407	29.427	39	55.5	50	41	49	52	47.3	.....	39.5	.212	.....	.334	.273
11	29.372	29.259	29.206	29.279	42	59.5	59	45	65	64	58	.....	40	.228	.368	.433	.343
12	29.179	29.138	29.138	29.152	62	65	61	64	69.5	66	66.5	.....	55	.529	.557	.470	.519
13	29.086	29.259	29.423	29.256	59	60	48.5	60	63	53	58.7	.....	55.5	.487	.478	.382	.449
14	.....	29.597	29.546	29.572	....	53	50.5	--	55	54	54.5	.....	42	.....	.376	.324	.349
15	29.400	.....	.....	29.400	68	.....	.....	71	.....	.....	71.0	.....	.....	.644	.....	.....	.644
16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	29.418	29.451	29.488	29.452	68	76	66	72.5	80	68	73.5	.....	51	.624	.843	.612	.693
18	29.443	29.493	29.598	29.511	66	74.5	65	73	79	67.5	73.2	.....	58.5	.545	.792	.584	.640
19	29.509	29.396	29.291	29.399	57	67	68	59	70	71	66.7	.....	55	.479	.622	.644	.582
20	29.276	29.401	29.583	29.420	66	60	57	5 68.5	63	60	63.8	.....	58	.606	.478	.449	.508
21	29.522	29.488	29.464	29.491	37	59.5	57.5	40	62	61	54.3	.....	44	.181	.482	.426	.363
22	.....	29.468	29.393	29.287	....	64.5	63.5	....	68	66	67.0	.....	54	.....	.559	.552	.556
23	29.714	29.697	29.616	29.676	54	57	56	56.5	59	59.5	58.3	.....	55	.385	.439	.403	.409
24	.....	29.371	29.251	29.211	....	64	64	....	68	67	67.5	.....	52	.....	.543	.556	.550
25	29.363	29.496	29.540	29.466	53	53	49	56	57.5	51	54.8	.....	51	.363	.343	.321	.342
26	29.602	.....	29.422	29.512	55	....	48	57	....	51	54.0	.....	47	.407	.....	.296	.352
27	29.384	29.267	29.302	29.318	52	56	58	54	58	52	54.7	.....	37	.362	.432	.....	.392
28	29.206	29.115	29.100	29.140	49	63	63	51.5	67	67	61.8	.....	47.5	.315	.522	.522	.453
29	29.316	.....	29.482	29.399	49	.....	43	52	.....	44	48.0	.....	41.5	.308	.....	.264	.281
30	29.570	29.512	29.431	29.504	45	45	44	47	48	46	47.0	.....	36	.273	.260	.262	.265
Means....	29.377	29.369	29.374.	20.365	54.1	60.6	57.4	56.9	63.4	60.0	60.8	.....	35.5	.386	.492	.445	.446
Oct. 1	.....	29.136	.....	29.136	....	58	.....	.....	60	.....	60.0	.....	.....	.....	.456	.....	.456
2	28.935	28.991	29.204	29.043	54	58	52	60	67	53.5	60.2	.....	46	.332	.363	.368	.356
3	29.372	29.307	29.285	29.321	37	49	45	39	54	47	43.3	.....	36	.194	.288	.273	.252
4	29.348	29.292	29.236	29.291	40	51	49	43	53	51	49.0	.....	35	.208	.348	.321	.292
5	29.194	29.355	29.487	29.345	47	52	45	51	56	47	51.3	.....	46	.270	.335	.273	.293
6	29.683	.....	29.433	29.558	36	.....	43	38	.....	45	41.5	.....	35	.186	.....	.251	.218
7	29.842	29.767	29.713	29.774	35	49	48	36.5	51	50	45.8	.....	34	.184	.321	.309	.271
8	29.617	29.467	29.320	29.435	49	55	50	53	57	54	54.7	.....	46	.295	.407	.308	.337
9	.....	28.851	.....	28.851	....	60	.....	.....	67	.....	67.0	.....	.....	.....	.425	.....	.425
10	28.719	28.741	28.773	28.743	52	51	48	55	52	50	52.3	.....	48	.349	.361	.309	.340
11	28.931	.....	.....	28.931	45	.....	.....	47	.....	.....	47.0	.....	.....	.273	.....	.....	.273
12	29.173	29.282	29.327	29.201	49	50	46	50	51	48	49.7	.....	46.5	.335	.348	.284	.322
13	29.372	.....	.....	29.372	44	.....	.....	45	.....	.....	45.0	.....	.....	.275	.....	.....	.275
14	29.327	29.249	29.215	29.264	33	54	55	36	56	57	49.7	.....	32	.149	.391	.407	.316
15	29.338	29.330	29.355	29.341	37	55	52	39	57	54	50.0	.....	35	.194	.477	.392	.321
16	29.390	29.256	29.284	29.310	43	60	64	46	62	67.5	58.5	.....	40	.238	.491	.549	.426
17	29.214	.....	29.171	29.193	59	.....	61	61	.....	63	62.0	.....	58	.473	.....	.510	.492
18	29.195	29.137	29.207	29.180	50	67	55	53	70	58	60.3	.....	51	.324	.622	.393	.445
19	29.297	29.284	.....	29.290	54	67	.....	57	70	.....	63.5	.....	.....	.378	.622	.....	.500
20	29.413	29.343	29.386	29.381	50	64	56	52	66	59	59.0	.....	49	.314	.569	.409	.464
21	29.176	29.132	29.357	29.222	57	65	48	61	67	50	59.3	.....	51	.412	.591	.309	.404
22	.....	29.485	29.615	29.500	....	47	39	....	50.5	40	30.2	.....	36.5	.....	.277	.225	.251
23	29.748	29.742	29.670	29.720	34	42	40	37	47	43	42.3	.....	30	.157	.232	.208	.199
24	29.700	29.690	29.695	29.695	32	48	40	35	53	42	43.3	.....	29	.142	.269	.221	.211
25	29.714	29.648	29.625	29.662	31	38	49	32	42	52	42.3	.....	28	.151	.177	.308	.212
26	29.598	29.635	.....	29.617	35	50	.....	37	55	.....	30.7	.....	.....	.178	.295	.....	.237
27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Means....	29.340	29.324	29.368	29.321	43.7	54.1	46.9	46.2	57.4	49.1	50.7	.....	28	.262	.390	.314	.355

the northern and northwestern lakes at Tawas City, Michigan.

VAPOR.				WIND.							Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.831	.472	.....	.652	NE ...	NE ...	NE ...	10	20	18	13.3	N. 45 W.	10	10	10	.....	.....
.807	.822	.882	.837	NW...	S	SW ..	5	17	8	7.0	S. 25 W.	2	0	0	.....	.....
.780	.772	.769	.774	S	SW ..	W	5	25	6	11.0	S. 46 W.	10	2	0	.....	.....
.889	.735	.893	.839	W	S	S	2	10	6	5.7	S. 7 W..	0	0	0	.....	.....
.718	.810	.856	.795	S	S	S	12	14	6	10.7	South ..	0	1	10	.....	.....
.809	.772	.729	.770	NW...	NW...	NW...	10	18	2	10.0	S. 45 W.	1	4	1	.....	.....
.900	.793	.774	.822	NW...	SE....	NW...	4	15	2	3.0	S. 45 E.	1	1	1	.....	.....
.753	.....	.895	.824	S	.....	S	10	....	13	7.7	South ..	1	....	3	.....	.....
.886	.848	.703	.812	W	NW...	NW...	2	12	18	10.7	N. 47 W.	10	7	10	.....	.....
.824	.....	.861	.843	W	SE....	NW...	3	14	3	3.0	N. 32 E	1	9	0	.....	.....
.762	.686	.727	.725	W	S	S	3	18	4	7.7	S. 8 W..	0	1	1	.....	.....
.888	.773	.735	.799	W	S	NW...	4	16	2	5.0	S. 21 W.	0	9	9	.....	.....
.940	.831	.699	.823	SW ..	W	N	8	6	14	4.7	N. 53 W.	10	2	1	.....	.53
.....	.869	.769	.819	.....	E	E	....	6	16	7.3	East ...	....	1	1	.....	.....
.850	.....	.....	.850	SW ..	.....	.....	8	....	....	2.7	S. 45 W.	3	....	....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.783	.824	.895	.834	SW ..	SW ..	SW ..	2	14	3	6.3	S. 45 W.	10	10	0	.....	.....
.672	.800	.868	.780	SW ..	SW ..	SW ..	3	8	14	8.3	S. 45 W.	9	5	0	.....	.....
.878	.848	.850	.859	NW...	SW ..	SW ..	2	13	16	9.7	S. 47 W.	10	10	8	.....	.....
.870	.831	.851	.851	NW...	NW...	NW...	8	10	3	7.0	N. 45 W.	10	10	5	.....	.50
.732	.883	.796	.804	W	W	W	3	9	2	4.7	West...	0	8	3	.....	.....
.....	.818	.865	.842	.....	NW...	NW...	....	13	8	5.0	S. 76 W.	....	1	8	.....	.....
.842	.878	.791	.837	NE ...	NE ...	NE ...	15	15	10	13.3	N. 45 E	9	1	0	.....	.....
.....	.793	.841	.817	.....	S	S	....	13	9	7.3	South ..	....	5	0	.....	.....
.809	.725	.859	.798	W	NW...	NW...	4	8	1	4.7	N. 57 W.	0	10	1	.....	.....
.874	.....	.790	.832	W	.....	W	12	....	8	6.7	West ..	10	....	10	.....	.....
.867	.876	.....	.872	W	S	W	6	16	3	6.3	S. 29 W.	0	5	0	.....	.....
.826	.790	.790	.802	W	S	W	2	10	4	4.0	S. 30 W.	0	0	1	.....	.....
.794	.....	.918	.856	NW...	.....	NW...	25	....	10	11.7	N. 45 W.	10	....	1	.....	.....
.847	.777	.843	.822	NW...	SE....	SW ..	14	4	2	3.3	N. 56 W.	10	10	10	.....	.....
.824	.793	.817	.813	.....	.....	.....	....	.....	....	2.4	S. 64 W.	4.9	4.9	3.4	.....	1.03
.....	.880	.....	.880	.....	S	.....	....	15	....	5.0	South ..	....	4	....	.....	.....
.653	.550	.899	.701	S	N	N	5	7	4	2.0	North ..	9	8	4	.....	.....
.816	.674	.687	.779	NW...	S	N	8	10	10	2.7	N. 45 W.	2	3	6	.....	.....
.750	.864	.859	.824	N	S	N	8	10	10	2.7	North ..	9	10	10	.....	.....
.722	.747	.847	.772	NW...	N	NW...	8	16	6	9.0	N. 21 W.	10	10	10	.....	.....
.811	.....	.840	.826	W	.....	W	8	....	6	4.7	West ..	10	....	10	.....	.....
.853	.859	.856	.856	W	E	SE....	4	4	13	4.3	S. 45 E .	6	4	0	.....	.....
.733	.874	.738	.782	SE....	SW ..	S	10	10	13	9.1	South ..	10	0	8	.....	.....
.....	.642	.....	.642	.....	SW ..	.....	....	18	....	6.0	S. 45 W.	....	5	....	.....	.....
.805	.930	.856	.864	SW ..	SW ..	SW ..	9	6	3	6.0	S. 45 W.	10	10	10	.....	.....
.847	.....	.....	.847	SW ..	.....	.....	3	....	....	1.0	S. 45 W.	10	....	....	.....	.....
.927	.929	.850	.902	NE ...	NW...	NW...	20	20	6	11.0	N. 7 W..	10	10	10	.....	.65
.920	.....	.....	.920	NW...	.....	.....	8	....	....	2.7	N. 45 W.	0	....	....	.....	.....
.705	.872	.874	.817	NW...	S	W	3	15	8	5.3	S. 39 W.	0	0	10	.....	.....
.816	.874	.867	.852	W	SE....	E	12	4	12	1.3	S. 45 E .	0	0	1	.....	.....
.767	.884	.817	.823	S	S	S	3	5	6	4.7	South ..	0	7	0	.....	.....
.882	.....	.886	.884	SW ..	.....	W	4	....	3	2.0	S. 61 W.	9	....	0	.....	.....
.798	.848	.816	.821	W	W	W	11	18	2	10.3	West...	7	7	7	.....	.....
.812	.848	.....	.830	W	SE....	.....	3	8	....	2.0	S. 27 E .	10	4	....	.....	.....
.861	.891	.819	.857	W	W	W	2	8	18	9.3	West...	0	10	10	.....	.....
.769	.893	.856	.839	SW ..	SW ..	NW...	5	4	2	3.0	S. 57 W.	10	10	10	.....	.....
.....	.753	.910	.832	.....	W	W	....	15	2	5.7	West...	....	7	0	.....	.34
.712	.624	.750	.695	W	W	W	8	3	7	5.3	N. 79 W.	0	0	0	.....	.....
.698	.667	.829	.731	W	S	W	6	16	7	7.0	S. 39 W.	0	0	0	.....	.....
.800	.661	.794	.752	NW...	SE....	E	2	2	10	3.3	East ...	1	1	2	.....	.....
.807	.681	.....	.744	NW...	NE ...	.....	6	8	....	3.3	N. 9 E ..	6	5	....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
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.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.794	.793	.850	.814	.....	.....	.....	....	...	....	2.2	S. 76 W.	5.6	5.2	5.4	.....	.99

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Nov. 1	.....	.....	.....	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
2	.....	.....	.....	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
3	.....	.....	.....	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
4	.....	.....	.....	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
5	29.441	29.402	29.456	29.433	32.5	48	35	35	52	37	41.3	....	27	.152	.222	.178	.204
6	.....	.....	.....	.....	....	....	....	....	....	....	.....	....	....	....	....	....	....
7	29.175	29.071	29.084	29.110	42	47.5	44.5	44	50	47	47.1	....	39.5	.241	.296	.261	.266
8	29.020	28.830	28.797	28.889	50	54.5	56	55	56	58	56.3	....	27.5	.295	.401	.422	.372
9	28.901	28.943	29.071	28.972	46	50	46	50	55	48	51.0	....	28	.258	.285	.284	.276
10	29.159	29.109	29.217	29.162	45	40	40	50	55	44	49.7	....	40	.234	.051	.195	.160
11	29.266	29.295	29.403	29.321	34	37	35	37	39	37	37.7	....	29	.157	.194	.178	.176
12	29.504	29.458	29.386	29.449	29	33	32.5	30	35	34	36.3	....	28	.149	.162	.165	.158
13	29.259	29.269	29.117	29.215	32	38.5	40	37	42	42	40.3	....	30	.116	.187	.221	.175
14	29.045	29.092	29.376	29.171	36	43	30	38	45	31	38.0	....	31	.186	.251	.155	.197
15	29.517	.....	29.022	29.270	25	....	17	27	....	42	34.5	...	23	.112	....	.155	.133
16	29.246	29.385	29.433	29.355	31	33	36	32	35	32	33.0	....	31	.162	.162	.....	.164
17	29.196	29.237	29.376	29.270	30	35	27	32	37	29	32.7	....	30.5	.144	.178	.124	.149
18	29.418	29.407	29.448	29.424	19	24	24	21	26.5	25.5	24.3	....	18	.080	.100	.112	.097
19	29.535	29.454	.....	29.495	13	33	....	15	35	....	25.0	....	....	.056	.162	.....	.109
20	29.199	29.224	29.258	29.227	34	44	41.5	36	48	44	42.7	...	31.5	.170	.236	.229	.212
21	29.353	.....	29.248	29.300	35	....	41	37	....	42.5	26.5	....	28.5	.178	...	.238	.208
22	29.249	29.167	29.156	29.191	40	47	37.5	42	49	40	43.7	....	34	.221	.297	.192	.237
23	29.292	.....	.....	29.292	39.5	....	....	41	....	....	41.0	....	....	.223	.....	.....	.223
24	29.148	.....	29.160	29.154	47	....	50	49	....	52.5	33.8	....	39	.297	....	.338	.313
25	29.022	28.972	29.272	29.089	46	44	34	48	46	36	43.3	....	35	.284	.262	.170	.239
26	29.344	29.427	29.495	29.422	31	33	33	33	35	35	34.3	....	32	.151	.162	.162	.158
27	29.423	29.321	29.244	29.329	33	29	36	35	31	38	34.7	....	31	.162	.137	.186	.162
28	29.314	.....	.....	29.314	35	....	....	36.5	....	....	36.5	....	....	.184	.....	.....	.184
29	28.900	28.961	28.980	28.947	35	24	13	36	26	15	25.7	....	14.5	.191	.106	.056	.118
30	29.283	.....	.....	29.283	6	....	....	7	....	....	07.0	....	....	.046	.....	.....	.046
Means....	29.248	29.212	29.237	29.363	33.8	38.8	36.6	36.1	42.0	38.5	36.7	....	14.5	.178	.206	.191	.192
Dec. 1	29.156	29.203	29.349	29.236	35	28	27	36.5	30	29	31.8	....	14	.184	.130	.124	.146
2	29.262	29.163	29.287	29.237	23	20	19	25	31.5	21	25.8	....	18	.100	.150	.080	.110
3	29.178	29.076	.....	29.127	15	19	....	17	21	....	19.0	....	....	.063	.080	.....	.072
4	29.077	29.073	29.028	29.059	15.5	21	13	17.5	23	16.5	19.0	....	13.5	.065	.090	.039	.065
5	28.571	.....	.....	28.571	30	....	....	32	....	....	32.0	....	....	.144	.....	.....	.144
6	29.170	29.149	29.254	29.191	19	23.5	14.5	21	26	18	21.7	....	13.5	.080	.097	.....	.089
7	29.491	29.427	29.422	29.447	9.5	16	13.5	13	19	16	16.0	....	11.5	.027	.056	.....	.042
8	29.474	29.438	29.110	29.341	14.5	20	26	17	22	28	22.3	....	11.5	.055	.085	.....	.070
9	29.270	29.243	.....	29.257	19	19	....	21	21	....	21.0	....	....	.080	.080	.....	.080
10	29.280	29.315	.....	29.202	13	21	....	15	23	....	19.0	....	....	.056	.090	.....	.073
11	29.379	29.416	.....	29.298	10	11	....	12	13	....	12.5	....	....	.046	.049	.....	.048
12	29.521	29.478	29.501	29.500	14	17	9.5	16	19	12	15.7	....	9.5	.059	.071	.....	.065
13	29.403	29.328	29.364	29.365	15	19	18.5	17	21	21	19.7	....	12.5	.063	.080	.....	.072
14	29.279	.....	29.173	29.226	18	....	18.5	20	....	21	20.5	....	12	.076	....	.....	.076
15	29.227	29.202	29.173	29.201	19	23	22	21	25	23	23.0	....	16.5	.080	.100	.....	.090
16	28.880	.....	29.216	29.043	23.5	....	25.5	25	....	27.5	26.3	....	20	.109	....	.....	.109
17	29.442	29.561	29.682	29.562	19	15	2	21	18	3	14.0	....	2	.080	.032	.....	.056
18	29.734	29.651	.....	29.093	-5	14	....	-3	17	....	04.7	....	....	.012	.048	.....	.030
19	29.150	29.282	29.293	29.242	21	26	23	23	28	25	25.3	....	8	.090	.117	.....	.103
20	29.618	29.490	29.482	29.390	13.5	26	29	16	28	30	24.7	....	15	.032	.117	.....	.074
21	28.970	28.807	28.942	28.906	27	32	30	30	34	32	32.0	....	30	.113	.155	.....	.134
22	29.404	29.546	29.523	29.491	23	25	25	26	27	27	23.7	....	22	.089	.112	.....	.100
23	29.170	29.100	29.298	29.189	26.5	28	33	28	32	35	31.7	....	25.5	.126	.108	.....	.117
24	29.073	28.720	.....	28.897	33.5	35	....	35	38	....	24.3	....	....	.172	.165	.....	.168
25	29.231	29.275	29.179	39.228	30	33	25.5	33	35	27	31.7	....	24	.133	.161	.....	.147
26	28.769	28.705	29.059	28.844	33	37	32	35	39	35	36.3	....	31.5	.162	.194	.....	.178
27	29.362	29.314	.....	29.225	24	30	...	26	33	....	19.7	....	....	.106	.132	.....	.119
28	29.583	.....	29.672	29.628	15	....	16	17	....	18	17.5	....	15	.063	....	.....	.063
29	29.800	29.770	29.949	29.839	11	18	10	13	22	12	15.7	....	10	.049	.053	.....	.051
30	29.673	29.518	.....	29.596	0	21	....	3	24	....	09.0	....	....	.010	.075	.....	.042
31	29.300	28.746	28.888	28.978	22	31.5	19.5	24	33	25	27.3	....	18	.095	.152	.....	.123
Means....	29.287	29.259	29.292	29.258	19.1	23.7	20.5	21.1	26.0	22.8	22.0	....	2	.085	.104	.080	.089

the northern and northwestern lakes at Tawas City, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
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.....	.....	.....	.....	.....	.....	.....	....	....	....	....	.....	....	....	....	.....	.....
.....	.....	.....	.....	.....	.....	.....	....	....	....	....	.....	....	....	....	.....	.....
.....	.....	.....	.....	.....	.....	.....	....	....	....	....	.....	....	....	....	.....	.....
.747	.727	.807	.760	W	SW...	NW..	18	30	3	15.3	S. 65 W.	0	4	0	.....	.....
.836	.820	.809	.822	S	S	S	12	4	3	6.3	South..	10	7	10	.....	.....
.681	.903	.876	.820	S	S	SW...	4	10	10	7.7	S. 18 W.	10	10	10	.....	.31
.716	.681	.850	.749	S	S	S	8	20	14	14.0	South..	1	0	0	.....	.56
.646	.119	.677	.481	W	W	W	15	22	16	17.7	West..	0	3	3	.....	.....
.712	.816	.807	.778	W	NW..	NW..	12	16	4	10.0	N.62 W.	0	9	6	.....	.....
.890	.797	.843	.843	NW..	NW..	N.....	8	14	11	10.3	N.30 W.	3	4	10	.....	.....
.527	.702	.829	.686	NW..	NW..	NW..	15	2	2	6.3	N.45 W.	9	4	9	.....	.....
.811	.840	.893	.848	NW..	NW..	NW..	10	25	4	13.0	N.45 W.	8	10	1	.....	.....
.761	.....	.577	.669	NW..	.....	SW...	2	....	14	4.7	S. 53 W.	10	....	9	.....	.....
.896	.797	.....	.847	NW..	NW..	NW..	30	28	20	26.0	N.45 W.	5	10	10	.....	.....
.794	.807	.775	.792	SE....	NW..	NW..	2	18	30	15.3	N.45 W.	10	10	10	.....	.....
.712	.699	.812	.741	NW..	NW..	NW..	15	20	14	16.3	N.45 W.	8	1	9	.....	.....
.648	.797	.....	.723	SW...	SW....	.....	6	10	....	5.3	S. 45 W.	10	9	....	.....	.....
.802	.704	.796	.767	SW...	W	SW...	6	8	5	5.7	S. 64 W.	6	9	5	.....	.....
.807	.....	.873	.840	S	.....	S	8	....	5	4.3	South..	10	....	10	.....	.....
.829	.853	.776	.819	W	SE....	S	2	5	10	4.7	S. 6 E..	10	10	10	.....	.10
.867	.....	.....	.867	W	.....	.....	2	.....	.....	0.7	West..	10	.....	.....	.....	.....
.853	.....	.829	.841	SE....	.....	SW...	5	....	12	4.3	S. 21 W.	10	....	10	.....	.....
.850	.843	.802	.832	NW..	NW..	NW..	8	10	10	9.3	N. 45 W.	10	10	10	.....	.....
.800	.797	.797	.798	SW...	W	NW..	2	2	2	1.6	West ..	10	10	10	.....	.....
.797	.788	.811	.799	W	SW...	SW...	8	10	10	9.0	S. 57 W.	10	10	10	.....	.....
.853	.....	.....	.853	NE	.....	.....	2	.....	.....	0.7	N. 45 E	10	.....	.....	.....	.....
.900	.754	.648	.767	NW..	NW..	NW..	25	20	25	23.3	N.45 W.	10	10	10	.....	.....
.769	.....	.....	.769	N.....	.....	.....	2	.....	.....	0.7	North ..	0	.....	.....	.....	.....
.779	.749	.794	.780	.....	.....	.....	....	....	....	6.0	N. 78 W	7.2	7.4	7.7	.....	.97
.853	.782	.775	.800	W	W	W	8	15	2	8.3	West...	10	10	8	.....	.....
.746	.843	.712	.767	W	W	W	10	18	5	11.0	West...	4	10	10	.....	.....
.671	.712	.....	.692	W	W	.....	8	8	....	5.3	West ..	10	10	....	.....	.....
.676	.730	.420	.609	W	W	W	5	10	2	5.7	West...	0	0	0	.....	.....
.794	.....	.....	.794	S	.....	.....	10	.....	.....	3.3	South..	8	.....	.....	.....	.....
.712	.694	.448	.618	NW..	NW..	NW..	10	20	2	10.7	N. 45 W.	5	3	1	.....	.....
.346	.541	.575	.487	NW..	W	W	3	16	3	7.3	N. 84 W.	2	6	0	.....	.....
.589	.721	.768	.693	W	SW...	SW...	6	10	2	5.7	S. 60 W.	3	8	10	.....	.....
.712	.712	.....	.712	W	NE	.....	3	10	....	2.7	N. 31 E	10	10	....	.....	.....
.648	.730	.....	.689	NW..	NE	.....	3	10	....	3.7	N. 27 E	10	10	....	.....	.....
.610	.623	.....	.617	NW..	NW..	.....	8	16	....	6.0	N. 45 W.	10	10	....	.....	.....
.659	.692	.513	.621	NE ..	NE ..	NE ..	10	16	15	13.7	N. 45 E	6	9	5	.....	.....
.671	.712	.641	.675	N.....	N.....	N.....	12	8	3	7.7	North ..	10	10	10	.....	.....
.702	.....	.641	.672	NW..	.....	SW...	2	....	3	1.3	S. 80 W.	10	....	10	.....	.....
.712	.746	.864	.774	SW...	SW...	NE ...	2	2	2	0.7	S. 45 W.	10	10	10	.....	.07
.809	.....	.765	.787	W	.....	W	2	....	2	1.3	West...	10	....	10	.....	.05
.712	.525	.730	.656	NW..	NW..	W	4	10	2	5.0	N. 49 W	10	6	....	.....	.....
.317	.509	.....	.413	NW..	SW....	.....	4	10	....	3.7	S. 64 W.	4	8	....	.....	.....
.730	.768	.746	.748	SW...	SW..	SW...	5	8	6	6.3	S. 45 W.	10	10	5	.....	.08
.575	.768	.890	.744	NE ...	NE ...	NE ...	2	10	30	14.0	N. 45 E	10	10	10	.....	.....
.675	.792	.794	.754	NE ...	SW..	SW...	10	25	15	10.0	S. 45 W.	10	10	10	.....	.....
.634	.761	.761	.719	NW..	SE....	S	2	2	18	6.0	South..	10	9	10	.....	.....
.826	.594	.797	.739	W	SW...	NE ...	5	4	4	1.7	West ..	10	10	10	.....	.....
.847	.719	.....	.783	SE....	SW.....	.....	5	2	....	1.7	S. 25 E	10	7	....	.....	.80
.703	.797	.821	.774	SW...	SW...	E	2	4	5	1.7	S. 9 E	1	10	10	.....	.25
.797	.816	.698	.770	SE....	SW...	W	2	12	15	8.0	S. 67 W.	10	10	9	.....	.12
.754	.703	.....	.729	NW..	W	.....	2	12	....	4.7	N. 84 W.	10	3	....	.....	.....
.671	.....	.682	.677	SW...	.....	SW...	3	....	13	5.3	S. 45 W.	10	....	10	.....	.....
.623	.449	.610	.561	NW..	NE ...	W	6	4	3	2.7	N.31 W.	10	0	....	.....	.....
.193	.610	.....	.402	W	W	.....	2	2	....	1.3	West	1	1	....	.....	.50
.738	.848	.318	.635	SW...	SE....	SW...	6	2	5	3.7	S. 34 W	10	10	10	.....	.....
.668	.700	.680	.681	.....	.....	.....	....	...	....	1.4	N. 74 W.	7.8	7.4	7.5	.....	1.87

Reductions of the monthly meteorological register of the sur

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, inches and mals.
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	9 p. m.
1867.					°	°	°	°	°	°	°	°	°		
Jan. 1	29.700	29.705	29.713	29.706	11	17	13	12	19	15	15.3	26	10	.061	.071
2	29.708	29.568	29.476	29.584	12	15	14	13	17	16	15.3	18	11	.063	.063
3	29.493	29.451	29.391	29.445	10	26	26	12	28	28	22.7	28	12	.046	.117
4	29.490	29.409	29.332	29.354	24	30	29	25	32	31	29.3	35	23	.117	.144
5	29.005	28.918	29.052	28.992	28	30	29	30	32	31	31.0	35	27	.130	.144
6	29.201	29.255	29.371	29.276	25	24	24	27	26	26	26.3	36	24	.112	.106
7	29.415	29.407	29.375	29.402	21	23	10	22	25	12	19.7	28	12	.101	.100
8	29.174	29.275	29.218	29.222	18	21	20	20	23	22	21.7	25	11	.076	.090
9	29.160	29.017	28.944	29.040	20	27	21	21	28	23	24.0	30	20	.096	.136
10	28.937	28.930	29.020	28.962	10	21	19	11	22	20	17.7	27	9	.057	.101
11	29.160	29.238	29.454	29.284	14	22	17	16	23	18	19.0	26	15	.059	.107
12	29.488	29.649	29.527	29.555	5	18	20	5	19	21	15.0	30	1	.055	.087
13	29.160	29.122	29.253	29.178	19	21	24	20	22	25	22.3	26	17	.092	.101
14	29.348	29.339	29.295	29.327	16	18	17	17	20	18	18.3	28	16	.078	.076
15	29.478	29.537	29.494	29.544	8	20	15	8	21	16	15.0	21	7	.062	.096
16	29.346	29.207	29.141	29.231	19	24	20	20	25	21	22.0	28	5	.092	.117
17	29.346	29.477	29.733	29.519	5	14	16	6	15	18	13.0	25	5	.043	.071
18	29.804	29.713	29.614	29.710	9	14	1	11	15	1	09.0	21	1	.043	.071
19	29.579	29.417	29.271	29.422	–9	12	1	–9	15	1	02.3	21	–11	.028	.041
20	29.164	28.937	28.865	28.989	3	15	16	4	17	18	13.0	21	– 7	.038	.063
21	28.854	28.950	29.112	28.972	18	21	18	19	23	19	20.3	24	16	.067	.090
22	29.299	29.340	29.437	29.359	15	21	20	16	23	21	20.0	24	13	.074	.090
23	29.576	29.611	29.661	29.616	18	20	19	19	22	21	20.7	24	17	.087	.085
24	29.797	29.751	29.715	29.754	20	24	22	21	26	24	23.7	27	19	.096	.106
25	29.380	28.858	28.828	29.022	22	27	31	23	29	32	28.0	33	21	.107	.124
26	28.932	28.994	29.094	29.007	21	23	21	23	26	22	23.7	35	21	.09	.089
27	29.275	29.350	29.498	29.374	10	18	13	11	20	14	15.0	26	11	.057	.076
28	29.546	29.467	29.476	29.496	10	14	6	11	16	7	11.3	17	6	.057	.059
29	29.582	29.567	29.657	29.602	1	10	3	1	12	3	05.3	15	1	.045	.046
30	29.707	29.666	29.529	29.634	–9	12	14	–11	14	16	06.3	15	–14	....	.052
31	29.415	29.269	29.028	29.237	18	32	41	19	36	42	32.3	43	15	.087	.129
Means....	29.369	29.335	29.341	29.348	13.3	20.4	18.1	14.3	22.3	19.4	18.7	43	–14	.074	.09
Feb. 1	29.210	29.280	29.305	29.265	35	31	25	36	35	26	32.3	47	25	.191	.1
2	29.056	28.684	28.566	28.769	24	29	32	26	30	33	29.7	36	23	.106	.1
3	28.676	28.836	28.993	28.825	24	28	23	25	31	24	26.7	37	23	.117	.1
4	29.069	28.897	28.848	28.938	20	29	28	21	31	30	27.3	32	11	.096	.1
5	29.169	29.319	29.434	29.307	28	31	27	30	36	29	31.7	37	26	.130	.1
6	29.469	29.601	29.656	29.575	22	29	21	23	33	22	26.0	35	21	.107	.1
7	29.685	28.611	29.534	29.610	21	35	32	22	42	38	34.0	45	20	.101	.1
8	29.422	29.279	29.149	29.280	16	36	35	17	45	39	33.7	49	17	.078	.1
9	29.129	29.092	29.291	29.171	22	18	14	27	20	15	20.7	42	13	.061	.1
10	29.728	29.914	30.034	29.892	–1	13	8	0	15	9	08.0	18	– 1	.030	.1
11	29.961	29.725	29.763	29.816	9	29	32	11	33	34	26.0	37	8	.042	.1
12	29.735	29.678	29.636	29.683	34	34	37	36	38	41	38.3	42	32	.176	.1
13	29.487	29.260	29.368	29.372	38	43	45	40	45	46	43.7	47	37	.208	.1
14	29.635	29.636	29.730	29.667	32	30	24	34	32	26	30.7	48	25	.153	.1
15	29.711	29.537	29.344	29.531	27	29	30	28	31	32	30.3	34	24	.132	.1
16	29.087	29.129	29.211	29.142	39	34	32	41	38	37	38.7	48	32	.218	.1
17	29.461	29.518	29.491	29.490	29	38	30	31	42	31	34.7	46	29	.125	.1
18	29.318	29.235	29.392	29.315	32	43	34	36	50	35	40.3	53	28	.181	.1
19	29.589	29.541	29.373	29.501	26	28	27	27	29	28	28.0	40	25	.181	.1
20	29.268	29.351	29.393	29.337	27	29	27	26	31	28	28.3	34	24	.181	.1
21	29.207	29.213	29.428	29.283	27	28	28	28	30	29	29.0	31	26	.181	.1
22	29.589	29.625	29.495	29.536	25	25	25	27	27	27	27.0	32	22	.181	.1
23	29.177	28.859	28.785	28.940	32	36	42	34	41	45	40.0	45	26	.181	.1
24	29.216	29.359	29.421	29.332	27	27	21	29	30	24	27.7	48	22	.181	.1
25	29.504	29.480	29.459	29.481	18	26	27	19	29	28	25.3	30	19	.181	.1
26	29.633	29.712	29.732	29.692	22	34	28	24	39	31	31.3	43	22	.181	.1
27	29.805	29.749	29.666	29.773	25	39	30	27	49	32	36.0	51	25	.181	.1
28	29.509	29.447	29.389	29.448	28	39	33	30	43	34	35.7	45	29	.181	.1
Means....	29.411	29.376	29.388	29.392	25.1	31.1	28.5	27.0	34.8	30.5	30.8	53	– 1	.181	.1

the northern and northwestern lakes at Detroit, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direct'n.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											o					
.804	.692	.648	.748	WNW	W	SW ..	1.0	4.3	4.5	3.0	S. 72 W	10	8	8	.....	.....
.810	.761	.659	.713	SW...	SW...	SW...	5.0	10.5	4.7	6.7	S. 45 W	10	3	3	.....	.....
.610	.768	.768	.715	SW...	SW...	SW...	1.0	5.0	7.0	4.3	S. 45 W	4	3	5	.....	.....
.872	.794	.788	.818	SSW	SSW.	SW...	2.5	4.0	4.0	3.3	S. 31 W	8	10	10	.....	.....
.782	.794	.788	.788	ENE.	NW...	NW...	1.0	4.0	6.0	3.3	N. 38 W	10	10	10	.....	.....
.761	.754	.754	.756	W	W	W	6.5	6.5	7.0	6.7	West...	8	10	10	.....	.02
.860	.746	.610	.739	W	W	W	4.0	4.5	0.3	2.9	West...	10	4	5	.....	.....
.702	.730	.721	.718	E.....	E NE	NW...	5.3	1.0	5.3	1.7	N. 30 E	10	10	10	.....	.....
.855	.883	.730	.823	W	W	W	2.0	2.7	2.0	2.2	West...	10	4	10	.....	.04
.797	.860	.850	.836	W	W	W	0.3	3.5	1.0	1.6	West...	10	6	10	.....	.....
.759	.864	.840	.788	W	W S W	W S W	3.0	2.5	2.5	2.7	S.77 W	10	6	7	.....	.02
1.000	.845	.855	.900	W	E	E	0.3	5.3	9.5	4.8	East ...	4	9	10	.....	.....
.850	.860	.872	.861	ENE.	NNE.	W S W	5.5	0 4	0.3	1.7	N. 62 E	10	10	10	.....	.22
.834	.702	.840	.792	N.....	ENE.	NE ...	2.0	7.0	4.5	4.0	N. 52 E	10	9	10	.....	.....
1.000	.855	.829	.895	NE....	SE....	SE ...	5.3	1.5	8.5	3.7	S. 72 E	8	10	10	.....	1.14
.850	.872	.855	.859	SSW .	SW ...	W	8.0	3.0	16.0	7.7	S. 66 W	10	10	10	.....	.....
.760	.823	.682	.755	W	WNW	NW...	13.5	11.7	9.0	10.7	N. 70 W	10	10	10	.....	.....
.596	.823	1.000	.806	NW ..	NW...	NW...	4.5	7.3	0.5	4.0	N. 45 W	10	4	5	.....	.....
1.000	.475	1.000	.825	NW ..	NW...	SW...	0.3	2.7	0.3	1.0	N. 51 W	3	3	5	.....	.....
.740	.671	.682	.698	NE ...	NE ...	NE ...	5.0	7.0	9.5	7.3	N. 45 E	10	10	10	.....	.....
.845	.730	.845	.807	N.....	WNW	NW...	8.5	7.0	3.5	5.3	N. 33 W	10	10	10	.....	.06
.829	.730	.855	.805	W	W	W	2.0	5.7	1.5	3.1	West...	10	10	10	.....	.....
.845	.721	.712	.759	NW ..	NW...	NW...	8.5	5.5	0.5	5.0	N. 45 W	10	10	10	.....	.....
.855	.754	.738	.782	NW ..	WNW	SE....	3.0	1.5	4.5	0.3	S. 45 W	10	10	10	.....	.....
.864	.775	.896	.845	ESE..	ESE.	E SE..	6.5	4.5	8.0	6.3	S. 67 E	10	10	10	.....	.....
.730	.634	.860	.741	W	W	W	6.7	8.5	6.0	7.1	West...	10	10	10	.....	.24
.797	.702	.816	.772	W	W S W	W S W	5.7	7.0	8.0	6.7	S. 74 W	7	10	10	.....	.....
.797	.659	.769	.742	SW..	SW...	SW ...	5 0	6.5	7.5	6.3	S. 45 W.	10	10	10	.....	.....
1.000	.610	1.000	.870	W	W	W	6.3	5.3	0.3	3.9	West..	8	3	5	.....	.....
.....	.635	.659	.647	W	S	SE ...	0.3	2.5	10.0	4.0	S. 34 E	4	6	10	.....	.....
.845	.610	.914	.790	S	SSW..	S S W.	1.0	2.5	11.0	4.7	S. 22 W	7	10	10	.....	.....
.818	.744	.801	.787	.....	.....	.....	....	....	....	1.9	S 84 W	8.7	8.0	8.8	.....	1.74
.900	.628	.876	.801	W	W	W	3.5	3.5	0.3	2.4	West...	8	9	7	.....	.....
.754	.890	.893	.846	ENE..	ENE..	E NE .	10.3	8.0	4.5	7.3	N. 67 E.	10	10	10	.....	.....
.872	.685	.868	.808	E.....	W	SW ...	0.5	0.5	2.0	0.7	S. 45 W.	10	10	6	.....	.92
.855	.788	.782	.808	SE ..	ENE..	NE ...	3.5	10.0	9.5	6.7	N. 66 E	10	10	10	.....	.....
.782	.550	.775	.702	W	W	W	8.0	7.3	3.0	6.1	West...	10	10	7	.....	.48
.864	.606	.860	.777	W S W	W S W	SW ...	4.3	4.7	5.0	4.3	S. 58 W.	9	3	6	.....	.....
.860	.420	.450	.577	SW...	SW...	SW ...	4.5	5.0	7.0	5.3	S.45 W.	4	6	8	.....	.....
.834	.314	.636	.598	S	SSW .	S S W.	1.0	8 0	4.5	5.3	S.21 W.	8	8	10	.....	.....
.415	.702	.823	.647	WN W	N	NW...	5.5	8.0	10.0	7.0	N. 35 W	10	10	10	.....	.....
.695	.648	.784	.709	W	W	W	3.5	5.7	6.5	5.2	West...	4	3	3	.....	.04
.596	.606	.792	.665	S	SSW .	S S W.	16.0	18.3	11.5	15.0	S.15 W.	8	7	10	.....	.....
.802	.628	.653	.694	SW...	SW...	SW ...	7.0	5.0	4.7	5.3	S.45 W.	10	10	10	.....	.....
.820	.840	.921	.860	SSE ..	SSW .	SW ...	7.3	13.0	1.0	6.7	S.8 W..	10	10	10	.....	.06
.792	.794	.754	.780	NE ...	NE ...	NE ...	7.0	6.0	6.5	6.3	N. 45 E.	10	10	10	.....	.58
.883	.788	.794	.822	E.....	E	E	6.7	12.5	8.5	9.2	East ...	10	10	10	.....	.....
.824	.628	.527	.660	SW...	W S W	W	6.5	11.0	7.5	8.0	S.69 W.	8	8	5	.....	.62
.788	.661	.893	.781	W	W	W	4.0	3.5	0.3	2.6	West...	4	7	8	.....	.....
.610	.615	.898	.674	S	W	NE ...	5.3	6.0	5.0	1.0	N. 52 W	10	3	10	.....	.....
.880	.887	.883	.883	NE ...	NE ...	NE ...	7.7	5.0	5.0	6.0	N. 45 E.	10	10	10	.....	.....
.....	.788	.883	.882	NE ...	NE ...	NE....	8.3	4.0	7.0	6.3	N. 45 E.	10	7	10	.....	.02
.883	.782	.887	.851	NE ...	NNW .	NW...	6.5	12.5	1.0	5.3	N. 3 W .	10	10	10	.....	.....
.761	.761	.761	.761	NW...	N	E	0.3	0.3	12.0	3.7	N. 87 E	10	10	10	.....	.....
.792	.567	.762	.707	S	SSW .	NW...	6.0	7.3	5.5	3.7	S.36 W	10	10	10	.....	.....
.775	.675	.610	.687	WN W	NNW.	NE ...	8.0	9.7	5.0	5.7	N. 26 W	8	7	9	.....	.....
.845	.665	.883	.798	NE ...	ENE..	E	3.0	4.5	5.5	4.0	N. 71 E.	7	6	9	.....	.....
.738	.547	.685	.667	W S W	SW...	NW...	0.5	4.0	3.0	2.3	N. 60 W	5	2	3	.....	.....
.761	.307	.794	.621	SW...	SW...	SW...	0.3	5.0	0.5	2.0	S.45 W.	0	2	4	.....	.....
.782	.669	.895	.782	SW...	WNW	SW...	0.3	1.0	2.5	1.3	S.45 W	5	10	8	.....	.....
.756	.686	.787	.743	.....	.....	.....	....	....	....	0.5	S.27 W.	8.1	7.8	8.3	.....	2.72

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Mar. 1	29.170	28.917	28.790	28.959	33	45	47	35	47	49	43.7	49	31	.162	.273	.297	.244
2	29.048	29.274	29.428	29.250	28	25	18	32	26	20	26.0	51	18	.108	.123	.076	.102
3	29.455	29.267	29.144	29.289	16	18	17	19	21	20	20.0	24	16	.056	.065	.060	.060
4	29.275	29.397	29.479	29.384	16	28	26	19	30	28	25.7	32	17	.056	.130	.117	.101
5	29.701	29.756	29.765	29.741	20	29	25	22	32	27	27.0	36	20	.085	.126	.112	.108
6	29.779	29.623	29.466	29.623	19	28	27	21	30	29	26.7	36	20	.080	.130	.124	.111
7	29.370	29.587	29.715	29.557	24	28	25	26	31	27	28.0	35	23	.106	.119	.112	.112
8	29.831	29.717	29.677	29.742	20	31	27	22	34	30	28.7	35	20	.085	.139	.113	.112
9	29.616	29.567	29.491	29.558	27	35	28	29	40	31	33.3	40	25	.124	.179	.119	.127
10	28.274	28.953	29.085	29.104	34	41	40	36	43	44	41.0	48	29	.170	.231	.195	.199
11	29.459	29.508	29.479	29.482	32	32	27	34	36	28	32.7	50	28	.155	.129	.136	.140
12	29.296	29.308	29.389	29.331	24	31	27	26	35	30	30.3	38	24	.106	.128	.113	.116
13	29.357	29.357	29.512	29.409	28	22	8	39	24	10	28.0	33	9	.130	.095	.040	.088
14	29.654	29.658	29.720	29.677	6	15	9	7	17	10	11.3	18	7	.046	.063	.054	.054
15	29.839	29.754	29.721	29.771	8	24	19	9	26	22	19.0	26	7	.051	.106	.069	.075
16	29.563	29.355	29.159	29.359	21	29	21	24	30	24	26.0	31	20	.079	.149	.079	.102
17	29.147	29.315	29.430	29.297	22	20	9	24	22	10	18.7	29	9	.095	.085	.054	.078
18	29.532	29.518	29.468	29.503	11	26	20	13	28	23	21.3	29	9	.049	.117	.074	.080
19	29.572	29.655	29.673	29.633	11	30	27	13	33	28	24.7	34	11	.049	.132	.136	.106
20	29.744	29.659	29.606	29.700	24	34	30	26	37	32	31.7	39	23	.106	.157	.144	.136
21	29.471	29.308	29.261	29.347	28	30	31	30	32	33	31.7	38	28	.130	.144	.151	.142
22	29.348	29.442	29.517	29.436	30	34	32	32	36	33	33.7	37	21	.144	.170	.168	.161
23	29.542	29.527	29.513	29.527	31	35	32	32	37	34	34.3	39	30	.162	.178	.155	.165
24	29.417	29.294	29.335	29.349	33	35	36	34	36	37	35.7	39	31	.175	.191	.199	.188
25	29.617	29.695	29.713	29.675	26	32	27	28	34	28	33.3	39	26	.117	.155	.136	.136
26	29.727	29.551	29.317	29.532	24	26	26	25	28	27	26.7	31	24	.117	.117	.129	.121
27	29.173	29.180	29.280	29.211	23	22	24	24	29	26	26.3	30	22	.112	.142	.106	.120
28	29.336	29.442	29.385	29.388	18	25	21	20	26	33	26.3	40	17	.076	.123	.090	.096
29	29.452	29.354	29.324	29.377	25	42	32	26	45	35	35.3	47	34	.123	.228	.142	.164
30	29.325	29.254	29.237	29.272	32	46	36	33	50	40	41.0	51	28	.168	.258	.168	.195
31	29.270	29.128	28.966	29.121	32	45	39	35	56	42	44.3	57	30	.142	.155	.199	.165
Means....	29.465	29.430	29.421	29.439	23.4	30.6	26.2	25.4	33.4	28.7	29.2	57	7	.109	.145	.124	.126
April. 1	28.909	28.951	29.055	28.972	33	38	34	34	44	37	38.3	47	31	.175	.151	.157	.161
2	29.298	29.387	29.516	29.400	32	40	30	35	49	35	39.7	50	32	.142	.130	.109	.127
3	29.574	29.431	29.323	29.443	31	44	42	35	51	46	44.0	54	31	.128	.209	.215	.184
4	29.175	29.102	29.086	29.121	45	48	40	54	51	43	49.3	57	41	.170	.296	.208	.225
5	29.010	28.990	29.141	29.047	33	33	30	36	35	31	34.0	47	29	.149	.162	.155	.155
6	29.321	29.181	29.172	29.225	29	40	35	31	49	43	43.7	50	26	.137	.130	.100	.122
7	29.202	29.299	29.360	29.287	37	41	40	45	51	44	46.7	53	38	.116	.126	.195	.146
8	29.280	29.438	29.518	29.412	40	41	34	44	46	38	42.7	50	37	.195	.192	.144	.177
9	29.680	29.552	29.434	29.555	33	43	38	36	48	42	42.0	48	31	.149	.212	.177	.179
10	29.294	29.108	29.204	29.202	36	37	37	38	39	39	38.7	44	37	.186	.194	.194	.191
11	29.391	29.365	29.343	29.366	30	40	34	31	46	37	38.0	52	29	.155	.169	.157	.160
12	29.298	29.242	29.190	29.243	36	47	42	39	58	46	47.7	60	31	.173	.178	.215	.189
13	29.360	29.369	29.389	29.339	40	48	45	45	62	52	53.0	63	36	.182	.151	.207	.180
14	29.415	29.333	29.265	29.338	45	51	47	52	64	52	56.0	67	45	.207	.202	.257	.222
15	29.178	29.113	29.079	29.123	48	52	52	51	55	54	53.3	58	48	.296	.349	.362	.336
16	29.059	29.165	29.398	29.207	45	48	42	47	53	45	48.3	56	44	.273	.269	.228	.257
17	29.440	29.508	29.578	29.509	40	44	37	48	61	48	52.3	61	40	.143	.065	.077	.095
18	29.714	29.705	29.624	29.681	35	41	40	42	51	44	45.7	53	32	.113	.196	.195	.145
19	29.515	29.424	29.341	29.427	38	47	46	43	57	50	50.0	60	40	.164	.191	.258	.204
20	29.148	29.038	29.138	29.108	50	49	44	56	67	51	58.0	67	47	.282	.110	.196	.196
21	29.260	29.199	29.118	29.192	37	46	43	41	58	49	49.3	59	37	.168	.153	.199	.173
22	28.849	29.005	29.274	29.043	35	36	34	37	41	36	38.0	52	33	.178	.147	.170	.165
23	29.451	29.564	29.548	29.521	31	34	35	33	39	38	36.7	41	31	.151	.181	.165	.149
24	29.498	29.491	29.520	29.503	33	38	39	36	42	42	40.0	45	34	.149	.177	.199	.175
25	29.562	29.509	29.460	29.510	38	46	41	41	55	47	47.7	58	35	.190	.192	.179	.187
26	29.370	29.148	29.124	29.214	43	46	40	48	58	50	52.0	61	42	.212	.153	.117	.161
27	29.405	29.536	29.507	29.483	29	35	32	33	41	36	36.7	53	31	.114	.126	.129	.123
28	29.494	29.455	29.396	29.448	34	40	35	39	49	41	43.0	49	31	.131	.130	.126	.129
29	29.284	29.152	29.099	29.178	41	52	53	44	59	58	53.7	61	31	.218	.296	.336	.283
30	29.189	29.182	29.187	29.183	53	53	42	58	63	45	55.3	64	44	.336	.270	.228	.278
Means....	29.321	29.298	29.312	29.310	37.7	43.3	39.4	41.7	51.4	44.3	45.8	67	26	.179	.179	.188	.182

the northern and northwestern lakes at Detroit, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.797	.847	.853	.832	E.....	S. SW.	SW....	0.5	7.0	3.5	3.3	S. 28 W.	10	10	10	.....	.....
.594	.876	.702	.724	W	NW ..	NE....	10.0	14.0	5.7	7.0	N. 49 W.	10	8	8	.....	.....
.541	.570	.556	.556	E. SE.	E	E. NE.	7.5	11.7	7.0	8.3	S. 89 E.	10	10	10	.....	.....
.541	.782	.768	.697	N. NE	W	W	1.0	5.5	2.5	2.3	N.83 W.	10	8	10	.....	.04
.721	.694	.761	.725	W	W	W	3.0	4.0	2.0	12.0	West..	10	4	6	.....	.....
.712	.782	.775	.756	E.	E	E	5.5	11.0	13.5	10.0	East...	8	10	10	.....	.....
.754	.685	.761	.733	N	N.NW	N.NW	8.5	9.5	2.0	6.7	N.13 W.	10	10	7	.....	.08
.721	.712	.675	.703	S. SW.	E. NE	E.....	0.7	3.5	2.0	1.7	N. 82 E.	5	9	10	.....	.....
.775	.557	.685	.672	N. NE	E.....	E.....	3.5	4.0	1.5	2.7	N. 58 E.	10	5	7	.....	.....
.802	.833	.677	.771	E. SE	S	W. SW	1.0	11.0	10.5	6.0	S. 28 W	10	10	10	.....	.....
.792	.610	.883	.762	W	E	E. NE.	2.0	4.0	7.0	3.0	N. 73 E.	10	10	10	.....	.08
.754	.628	.675	.686	N.....	N	E	10.5	6.7	4.5	6.0	N. 14 E.	10	3	10	.....	.10
.782	.728	.582	.701	S. S W	W	W	2.7	9.3	10.0	7.0	S. 83 W.	10	6	6	.....	.....
.769	.671	.791	.744	W	W	W	3.5	7.0	5.0	5.2	West ..	3	7	5	.....	.....
.784	.754	.584	.707	SW....	SW....	SW....	4.0	8.5	4.0	5.3	S. 45 W.	2	7	8	.....	.....
.610	.890	.610	.703	E	E	E	9.0	12.0	5 0	8.7	East....	9	10	10	.....	.....
.738	.721	.791	.750	W	W	W	6.5	11.0	6.0	7.8	West....	8	7	5	.....	.18
.623	.768	.598	.663	SW....	SW	SW....	5.5	4.7	4.0	4.7	S. 45 W.	7	4	3	.....	.....
.623	.703	.883	.736	S	E. SE .	E. NE	0.3	5.3	1.5	2.3	S. 75 E.	2	4	5	.....	.....
.754	.712	.794	.753	NE	E. NE	E.....	8.0	11.5	9.5	9.3	N. 67 E.	7	8	9	.....	.....
.782	.794	8 0	.792	E	E	E.....	8.7	9.0	6 0	7.9	East....	10	10	10	.....	.....
.794	.802	.893	.829	E. NE	E. NE	E. NE	1.7	3.0	1.0	2.0	N. 71 E.	10	10	10	.....	.40
.896	.807	.792	.832	E. NE	E. NE	E. NE.	0.3	4.0	1.3	2.0	N. 70 E.	10	7	10	.....	.....
.895	.900	.903	.899	E	E	W	0.3	0.5	6.0	1.7	West..	10	10	10	.....	.....
.768	.792	.883	.814	W.NW	N.NW.	N.NW.	10.5	11.0	2.5	5.7	N. 15 E	6	2	0	.....	.20
.872	.768	.880	.840	E	E	E	8.0	8.5	10.5	9.0	East....	10	10	10	.....	.....
.868	.887	.754	.836	NE ...	N.NW.	NW ..	8.0	6.0	5.0	4.7	N. 1 W..	10	10	10	.....	.14
.702	.876	.730	.769	N W ..	NW...	NW ..	4.5	10.5	5.0	6.7	N.45 W.	8	4	7	.....	.....
.876	.762	.698	.779	W	W	W	2.7	8.0	8.5	6.4	West ..	6	7	8	.....	.....
.893	.716	.645	.751	W	W	W	3.5	7.0	4.5	5.0	West...	2	3	3	.....	.....
.698	.346	.744	.596	W. SW	SW....	S	1.3	5.5	4.0	3.3	S. 30 W.	2	5	10	.....	.....
.749	.742	.746	.746	.....	.....	.....	....	....	....	0.7	N. 13 W.	7.9	7.4	8.0	.....	1.22
.895	.522	.712	.710	W	W	SW....	6.0	11.5	10.0	8.7	S. 73 W.	10	5	10	.....	.35
.698	.373	.537	.536	W	W	NE....	3.7	10.0	8.5	3.3	N.50 W.	4	3	5	.....	.....
.628	.581	.691	.633	E	S. SE..	S	2.3	15.5	8.3	8.0	S. 20 E.	8	7	8	.....	.....
.423	.790	.750	.654	SW...	SW....	SW....	6.5	8.0	8.5	7.7	S. 45 W.	10	10	10	.....	.....
.705	.797	.893	.798	W. SW	W. SW	W	3.0	2.5	19.0	8 0	S. 85 W.	10	10	10	.....	.32
.788	.373	.357	.506	SW ...	SW....	SW....	3.0	8.0	5.5	5.7	S. 45 W.	4	8	10	.....	.02
.386	.337	.677	.467	W. SW	W	W	3.7	4.7	0.3	3.0	S. 81 W.	8	10	10	.....	.....
.677	.617	.628	.641	NW...	NW....	NW....	4.0	11.0	1.5	5.3	N.45 W.	10	10	7	.....	.....
.705	.631	.661	.660	E	E	E	6.0	5.0	3.0	4.7	East....	4	5	10	.....	.....
.811	.816	.816	.814	E. NE	N. NE	NE....	4.0	7.0	0.3	3.7	N. 36 E.	10	10	10	.....	.14
.893	.543	.712	.716	N	E	SW ..	6.7	1.5	1.0	2.6	N. 7 E..	4	3	0	.....	.30
.736	.370	.691	.596	SW....	SW....	SW ..	1.5	4.0	1.0	2.0	S. 45 W.	0	3	4	.....	.....
.607	.270	.535	.471	S	S	S.	1.3	8.3	0.7	3.4	South ..	2	3	5	.....	.....
.535	.340	.660	.512	S. SE..	S. SW.	NE....	2.0	8.7	1.0	3.3	S. 11 W.	8	10	10	.....	.....
.790	.805	.867	.821	S. SE..	S	S.	10.5	11.5	1.5	7.7	S. 10 E.	10	10	10	.....	.14
.847	.667	.762	.759	E.	N	N.....	1.0	19.0	6.0	8.3	N. 3 E..	10	10	5	.....	.10
.426	.120	.228	.258	N.NW.	N.NW	NE....	14.0	9.7	4.7	8.7	N.12 W.	0	0	0	.....	.....
.420	.337	.677	.478	NE ...	NE ...	NE....	2.0	4.5	3.0	16.7	N. 45 E.	2	4	7	.....	.....
.587	.411	.716	.571	E.....	E. NE	SE....	1.5	3.5	0.3	1.7	N. 77 E.	8	9	10	.....	.....
.627	.166	.525	.439	SW....	SW....	SW ...	3.0	12.0	4.0	6.3	S. 45 W.	8	4	7	.....	.....
.653	.318	.572	.514	W.NW	W	SE....	2.3	3.3	7.0	1.3	S. 7 W.	6	9	10	.....	.....
.807	.567	.802	.725	N.....	N.NW.	NE....	11.7	13.0	4.0	9.0	N. 5 W.	10	10	10	.....	.56
.800	.547	.719	.689	NE ...	NE	NE....	6.3	3.7	2.5	4.0	N. 45 E.	10	10	10	.....	.08
.705	.661	.744	.703	N.....	SE....	SE....	3.5	1.5	4.5	1.3	S. 81 E.	10	10	10	.....	.....
.738	.445	.554	.579	SW	SW....	SW ...	2.0	5.0	2.5	3.0	S. 45 W.	5	6	8	.....	.....
.631	.318	.322	.424	S. SW	S. SW	W	9.0	17.0	4.0	9.3	S. 29 W.	8	10	10	.....	.....
.606	.488	.610	.568	N. NW	E.....	E. SE	11.0	4.3	7.0	3.7	N. 37 E.	10	7	10	.....	.18
.547	.373	.488	.469	S. SE..	E.....	E.....	7.0	9.0	8.5	7.0	S. 73 E.	5	5	10	.....	.....
.756	.592	.698	.682	E	S.....	SW ...	3.0	16.0	4.5	6.3	S. 1 W	1 0	10	10	.....	.....
.698	.470	.762	.643	W. SW	W. NW	NE....	4.0	6.5	5.0	2.7	N.57 W.	7	5	10	.....	.....
.670	.487	.645	.601	.....	.....	.....	....	....	....	0.5	S. 71 W.	7.0	7.2	8.2	.....	2.19

Reductions of the monthly meteorological register of the surgeon

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
May 1	29.211	29.232	29.290	29.244	37	45	37	40	57	41	46.0	60	39	.181	.142	.168	.164
2	29.564	29.602	29.609	29.592	25	33	31	31	41	37	36.3	46	29	.066	.084	.105	.085
3	29.720	29.679	29.579	29.659	33	38	36	38	46	40	41.3	47	25	.123	.125	.160	.136
4	29.315	29.240	29.169	29.241	45	54	52	50	58	55	54.3	65	35	.234	.365	.349	.316
5	29.171	29.246	29.307	29.241	45	50	45	57	65	53	58.3	67	49	.407	.163	.194	.255
6	29.312	29.263	29.247	29.274	43	43	37	45	49	43	45.7	57	41	.251	.199	.142	.197
7	29.297	29.287	29.299	29.291	35	38	37	37	45	40	40.7	48	35	.178	.138	.181	.166
8	29.275	29.208	29.148	29.210	36	41	38	40	51	42	44.3	53	35	.160	.126	.177	.151
9	29.152	29.076	29.019	29.082	37	45	46	42	58	52	50.7	59	32	.155	.129	.220	.168
10	29.206	29.245	29.166	29.206	43	48	46	47	59	53	53.0	62	51	.225	.190	.219	.211
11	29.359	29.329	29.412	29.367	38	49	41	46	62	47	51.7	64	34	.125	.176	.179	.160
12	29.523	29.455	29.385	29.454	38	45	46	43	59	53	51.7	60	35	.164	.115	.219	.166
13	29.212	28.976	28.953	29.047	44	60	50	46	69	55	56.7	68	54	.262	.398	.295	.318
14	28.974	29.059	29.028	29.020	43	45	45	46	47	46	46.3	58	42	.238	.273	.296	.269
15	28.960	29.056	29.183	29.066	42	46	45	43	53	49	48.3	55	41	.254	.219	.247	.240
16	29.212	29.234	29.243	29.230	44	49	45	48	59	49	52.0	60	38	.236	.216	.247	.233
17	29.339	29.473	29.541	29.451	40	45	41	42	53	45	46.7	55	40	.221	.194	.205	.207
18	29.668	29.584	29.549	29.607	42	51	47	49	59	53	53.7	62	36	.175	.269	.244	.229
19	29.496	29.374	29.306	29.392	45	44	44	50	53	48	50.3	57	45	.234	.170	.236	.213
20	29.317	29.310	29.244	29.290	45	50	46	47	57	50	51.3	58	44	.273	.268	.258	.266
21	28.981	28.770	28.773	28.841	45	49	49	48	52	51	50.3	54	46	.260	.308	.321	.296
22	28.777	28.938	28.967	28.894	42	43	41	45	45	44	44.7	54	42	.228	.251	.218	.232
23	29.062	29.148	29.229	29.146	40	45	41	42	52	46	46.7	57	40	.221	.207	.192	.207
24	29.289	29.265	29.220	29.258	45	50	48	52	62	58	57.3	64	40	.207	.202	.203	.204
25	29.167	29.055	29.162	29.128	47	52	42	54	54	50	52.7	62	48	.231	.262	.162	.252
26	29.215	29.264	29.347	29.275	42	50	48	47	57	52	52.0	60	42	.202	.268	.282	.251
27	29.509	29.478	29.540	29.509	47	48	44	51	56	61	56.0	57	41	.270	.230	.065	.188
28	29.282	29.250	29.186	29.239	45	53	34	56	57	57	56.7	59	45	.155	.350	.....	.253
29	29.317	29.360	29.373	29.350	52	55	48	55	62	53	56.7	67	51	.349	.340	.269	.319
30	29.486	29.396	29.459	29.447	48	57	42	52	66	49	55.7	71	46	.282	.346	.175	.268
31	29.598	29.582	29.501	29.560	45	52	47	49	59	51	53.0	61	37	.247	.296	.270	.271
Means....	29.290	29.272	29.272	29.278	42.2	47.7	43.2	46.4	55.5	49.1	50.3	71	25	.220	.230	.249	.232
June 1	29.474	29.290	29.127	29.297	48	58	55	52	66	61	59.7	70	42	.282	.376	.354	.337
2	28.973	28.952	28.915	28.948	61	62	58	63	74	63	66.7	75	59	.510	.396	.416	.441
3	28.981	29.109	29.161	29.084	55	57	53	58	62	56	58.7	66	55	.393	.399	.363	.385
4	29.249	29.382	29.324	29.318	58	63	55	60	75	60	65.0	79	51	.456	.415	.367	.413
5	29.444	29.388	29.330	29.387	56	65	60	61	73	65	66.3	76	49	.383	.510	.451	.448
6	29.311	29.309	29.266	29.295	64	64	62	70	67	66	67.7	83	60	.516	.556	.502	.530
7	29.357	29.304	29.355	29.339	64	69	65	67	79	69	71.7	81	58	.556	.574	.564	.565
8	29.474	29.414	29.476	29.455	61	66	56	65	75	60	66.7	76	60	.493	.519	.326	.466
9	29.525	29.491	29.479	29.498	56	62	60	63	74	62	66.3	77	62	.356	.396	.491	.414
10	29.548	29.448	29.433	29.476	60	62	56	64	70	64	66.0	75	51	.465	.449	.343	.419
11	29.431	29.388	29.335	29.385	60	66	64	67	74	67	69.3	76	61	.425	.532	.556	.504
12	29.374	29.354	29.456	29.395	64	66	61	66	73	65	68.0	82	62	.569	.545	.483	.532
13	29.509	29.458	29.437	29.478	62	65	64	66	74	68	69.3	77	57	.502	.497	.543	.514
14	29.414	29.311	29.313	29.346	69	68	64	74	80	68	74.0	84	60	.641	.524	.543	.569
15	29.281	29.240	29.233	29.251	65	68	68	70	71	71	72.0	77	63	.550	.591	.644	.595
16	29.352	29.443	29.412	29.402	63	66	53	66	74	63	67.7	75	62	.536	.532	.270	.446
17	29.381	29.269	29.296	29.315	60	70	67	69	80	69	72.7	83	55	.398	.598	.635	.544
18	29.456	29.501	29.572	29.510	58	60	55	62	70	60	64.0	74	55	.429	.385	.367	.394
19	29.623	29.557	29.577	29.586	56	60	55	60	71	61	64.0	75	47	.396	.371	.354	.374
20	29.528	29.521	29.529	29.526	59	61	59	62	71	64	65.7	73	52	.460	.403	.433	.432
21	29.580	29.513	29.482	29.525	60	67	60	62	74	65	67.0	76	53	.491	.568	.451	.503
22	29.477	29.465	29.408	29.450	65	72	66	70	81	72	74.3	83	55	.550	.663	.559	.591
23	29.395	29.361	29.312	29.356	68	71	66	73	80	72	75.0	84	61	.618	.637	.559	.605
24	29.250	29.192	29.204	29.215	68	70	68	72	79	72	74.3	81	64	.631	.612	.631	.625
25	29.193	29.197	29.245	29.212	70	71	69	74	74	72	73.3	79	68	.679	.718	.668	.688
26	29.293	29.286	29.293	29.291	61	69	65	66	81	71	72.7	84	60	.470	.547	.537	.518
27	29.370	29.223	29.322	29.305	66	68	61	72	80	65	72.3	83	65	.559	.524	.483	.522
28	29.470	29.520	29.542	29.511	60	62	59	65	68	62	65.0	72	58	.451	.476	.460	.462
29	29.530	29.422	29.345	29.432	61	68	66	65	79	70	71.3	81	51	.483	.576	.586	.550
30	29.225	29.151	29.230	29.202	65	75	62	71	86	69	75.3	91	67	.537	.719	.482	.579
Means....	29.381	29.350	29.347	29.359	61.4	65.7	61.1	65.8	74.6	65.7	68.7	91	42	.492	.519	.482	.498

the northern and northwestern lakes at Detroit, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.732	.305	.653	.563	NW...	NW...	NW...	8.5	12.3	3.3	8.0	N. 45 W.	10	7	10	.....	.04
.380	.328	.476	.395	NW...	NW...	NW...	13.0	11.0	3.0	9.0	N. 45 W.	4	5	6	.....	.....
.537	.400	.645	.527	SE....	SE....	SE....	8.0	11.0	7.0	8.7	S. 45 E.	5	5	10	.....	.....
.646	.756	.805	.736	SE....	S. S W	S. S W	9.5	13.0	5.3	7.7	S. 1 W.	8	10	10	.....	.....
.874	.264	.483	.540	SW...	SW...	SW...	4.0	8.7	5.0	6.0	S. 45 W.	10	10	10	.....	.60
.840	.572	.511	.641	SW...	SW...	SW...	5.0	6.5	4.0	5.0	S. 45 W.	10	10	10	.....	.....
.807	.459	.732	.666	W.NW	NW...	NW...	9.7	6.0	3.0	6.3	N. 57 W.	10	10	8	.....	.....
.645	.337	.661	.548	N.....	N.....	N.....	9.0	10.0	0.5	6.5	North ..	10	10	7	.....	.....
.577	.267	.590	.478	NW...	NW...	NW...	3.0	8.7	8.0	6.3	N. 45 W.	4	5	10	.....	.....
.698	.381	.544	.541	W	NW...	NW...	2.3	6.0	5.5	4.3	N 52 W.	10	5	5	.....	.....
.400	.317	.554	.424	N. NW	W	N.....	4.0	5.0	5.5	3.3	N. 10 W.	3	4	4	.....	.....
.587	.229	.554	.453	N. NW	E.....	E.....	2.5	5.0	5.7	3.3	N. 77 E.	0	8	9	.....	.76
.843	.564	.681	.696	E.....	SW...	W	7.0	3.0	5.0	0.7	S. 3 W.	10	7	6	.....	.....
.767	.847	.921	.845	W	W	W	4.7	5.3	4.5	4.8	West...	10	10	10	.....	.14
.916	.544	.710	.723	NW...	NW...	NW...	3.0	12.0	0.3	5.0	N. 45 W.	10	7	7	.....	.04
.704	.432	.710	.615	NW...	NW...	NW...	5.0	2.0	1.5	2.7	N. 45 W.	57	6	10	.....	.06
.829	.483	.684	.665	N. NW	NW...	NE	12.0	10.0	1.5	7.3	N. 29 W.	10	9	8	.....	.....
.505	.537	.606	.549	N. NW	E. NE	E.....	7.0	4.0	3.0	3.0	N. 28 E.	4	6	10	.....	.....
.646	.423	.704	.591	E.....	E.....	E.....	2.0	6.0	8.0	5.3	East....	10	10	10	.....	.24
.847	.577	.716	.713	E.....	E.....	E.....	4.0	3.5	4.0	3.8	East....	10	10	10	.....	.40
.777	.794	.859	.810	E.....	E.....	E.....	17.0	11.0	4.5	10.8	East....	10	10	10	.....	1.10
.762	.840	.756	.786	W.NW	W	NW...	7.0	4.7	5.0	5.3	N. 67 W.	10	10	10	.....	.40
.829	.535	.617	.660	W	W	W	4.5	6.0	1.0	3.8	West...	10	10	8	.....	.....
.535	.364	.421	.440	SW...	S	SE....	2.0	17.0	6.0	7.7	S. 7 E.	0	6	10	.....	.....
.552	.867	.450	.623	SW...	SW...	SW...	9.0	4.0	2.5	5.0	S. 45 W.	8	7	7	.....	.....
.624	.577	.727	.643	NW..	E. NE.	SE....	6.0	4.0	1.5	1.7	N. 9 E.	5	5	4	.....	.....
.722	.512	.120	.451	E. NE.	E. NE.	E.....	3.0	5.5	3.5	4.0	N. 75 E.	7	10	10	.....	.60
.346	.752	.....	.549	E.....	E.....	E.....	13.0	6.0	0.5	6.5	East....	10	9	10	.....	.....
.805	.612	.667	.695	W	W	W	3.0	6.5	3.5	4.3	West...	10	9	10	.....	.....
.727	.543	.505	.592	W.NW	SW...	NE ..	3.0	5.0	3.0	1.3	S. 85 W.	9	4	7	.....	.....
.710	.592	.722	.675	N.....	E. NE.	SW...	4.7	4.3	6.0	0.7	N. 9 W.	2	6	8	.....	.....
.683	.517	.626	.608	.....	.....	.....	....	....	....	1.0	N. 53 W.	7.5	7.7	8.5	.....	4.38
.727	.588	.659	.658	SE....	E. NE.	E.....	1.5	6.0	5.0	4.0	N. 84 E.	8	7	10	.....	.....
.886	.472	.723	.694	S	S. S W	S. SW.	12.0	7.7	6.0	8.3	S 12 W.	10	3	10	.....	.68
.816	.718	.809	.781	SW...	W. SW	W. NW	5.0	7.0	1.0	4.0	S. 61 W.	10	9	8	.....	.....
.880	.479	.708	.689	SW...	W	E.....	1.5	4.5	2.5	1.3	S. 76 W.	7	7	8	.....	.....
.713	.629	.731	.691	E. NE.	E.....	E.....	3.0	4.0	2.0	3.0	N 83 E.	8	6	7	.....	.....
.704	.841	.786	.777	SW...	SW...	SW...	2.3	3.5	2.5	2.7	S. 45 W.	6	10	10	.....	.04
.841	.580	.796	.739	SW...	E.....	E. ..	0.3	2.5	0.3	0.7	S. 78 E.	5	4	6	.....	.84
.783	.599	.765	.716	NE ...	E.....	NE	3.0	4.0	3.5	3.3	N. 63 E.	7	6	8	.....	.....
.619	.472	.884	.658	NE ...	E. NE.	S	4.5	3.0	0.5	2.3	N. 58 E.	4	5	5	.....	.....
.780	.613	.575	.656	E.....	E.....	E.....	5.0	11.0	10.0	8.7	East....	4	6	7	.....	.....
.642	.634	.841	.706	S	S	W	7.0	8.3	1.5	5.3	S. 5 W.	8	9	10	.....	.....
.891	.672	.783	.782	SW...	SW...	SE....	3.0	7.0	1.5	3.3	S. 37 W.	10	10	8	.....	.26
.786	.593	.793	.724	E.....	E.....	S. SW.	6.5	3.5	1.7	3.3	S. 80 E.	7	5	10	.....	.....
.764	.512	.793	.690	SW...	S. SW.	N. NE	2.0	17.0	3.0	5.3	S. 25 W.	5	8	8	.....	.....
.751	.681	.850	.761	W	S	S	1.3	13.0	2.5	5.3	S. 5 W.	9	7	10	.....	.....
.838	.634	.470	.647	NE ...	NE	NE	1.0	4.7	1.0	2.0	N. 45 E.	9	7	8	.....	.....
.564	.584	.896	.682	SE....	SE....	SW...	4.0	22.0	3.5	8.7	S. 37 E.	9	5	10	.....	.....
.772	.525	.708	.668	W	W	E.....	4.5	6.0	2.5	2.7	West...	4	5	7	.....	.72
.765	.490	.659	.638	N.....	NE	SW...	2.0	3.0	3.0	0.7	North ..	4	7	8	.....	.....
.828	.532	.727	.696	NE ...	NE	NE	0.3	4.0	0.3	1.3	N. 45 E.	9	9	8	.....	.....
.884	.677	.731	.764	E. NE.	E. NE.	E. SE.	4.0	3.5	1.5	3.0	N. 75 E.	10	4	4	.....	.....
.751	.627	.712	.697	SE....	SW...	SW...	1.5	1.0	0.5	0.7	South ..	5	6	8	.....	.....
.761	.623	.712	.699	S. SW.	E. NE.	E. SE..	0.5	3.0	11.0	4.3	S. 75 E.	7	5	8	.....	.....
.804	.618	.804	.742	E.....	E.....	E.....	5.7	6.0	4.0	5.2	East....	6	7	10	.....	.....
.810	.856	.852	.839	E.....	E.....	E.....	3.0	2.5	1.5	2.3	East....	7	9	10	.....	.....
.735	.518	.708	.654	W.NW	SW...	SW...	1.0	4.0	9.0	4.3	S. 50 W.	7	4	6	.....	.....
.712	.512	.783	.669	SW...	SW...	SW...	5.0	6.0	4.0	5.0	S. 45 W.	7	8	6	.....	.....
.731	.695	.828	.751	N. NW	E. NE.	E. NE.	7.0	6.5	2.5	3.3	N. 38 E.	6	4	8	.....	.....
.783	.542	.799	.708	NE ...	SW...	SW...	1.3	7.3	1.5	2.3	S. 45 W.	6	7	8	.....	.....
.708	.579	.653	.647	SW...	SW...	E.....	6.5	7.0	6.0	3.3	S. 20 W.	8	7	10	.....	.....
.767	.603	.751	.707	.....	.....	.....	....	....	....	1.2	S. 29 E.	7.1	6.5	8.1	.....	2.54

Reductions of the monthly meterological register of the surrey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
July 1	29.389	29.342	29.346	29.359	57	63	60	63	72	64	66.3	80	55	.386	.455	.465	.435
2	29.401	29.320	29.293	29.338	61	71	69	67	85	73	75.0	87	57	.457	.570	.655	.561
3	29.363	29.307	29.219	29.296	69	72	69	77	85	75	79.0	92	68	.641	.69	.629	.653
4	29.186	29.168	29.169	29.174	71	68	67	76	71	70	72.3	86	66	.691	.644	.622	.652
5	29.195	29.141	29.062	29.133	68	73	71	70	81	73	74.7	83	64	.658	.703	.731	.697
6	29.207	29.272	29.297	29.259	65	68	67	69	74	71	71.3	82	64	.564	.604	.608	.592
7	29.319	29.360	29.377	29.352	62	65	60	71	76	65	70.7	78	65	.644	.470	.451	.522
8	29.467	29.421	29.441	29.443	58	62	56	66	76	59	67.0	78	53	.376	.369	.409	.385
9	29.531	29.532	29.518	29.527	54	58	59	56	70	62	62.7	73	51	.391	.323	.460	.391
10	29.494	29.465	29.312	29.430	56	63	62	60	74	73	69.0	78	51	.396	.429	.419	.414
11	29.296	29.264	29.265	29.282	65	72	65	72	82	70	74.7	86	68	.524	.650	.550	.575
12	29.444	29.460	29.492	29.465	57	59	50	60	65	53	59.3	76	52	.426	.420	.321	.389
13	29.612	29.569	29.578	29.586	52	65	55	59	70	60	63.0	71	44	.296	.550	.367	.404
14	29.610	29.552	29.423	29.528	65	63	61	72	76	67	71.7	78	58	.524	.402	.457	.461
15	29.394	29.349	29.398	29.380	68	67	60	72	70	62	68.0	83	62	.631	.622	.491	.581
16	29.538	29.548	29.528	29.538	57	62	55	62	73	60	65.0	75	52	.389	.409	.367	.388
17	29.614	29.560	29.525	29.566	57	61	56	65	72	61	66.0	74	48	.359	.390	.361	.377
18	29.541	29.554	29.517	29.537	62	62	57	67	75	64	68.7	77	52	.489	.5[illegible]	.373	.45[illegible]
19	29.470	29.464	29.483	29.472	60	65	60	62	72	64	66.0	76	55	.491	.524	.465	.493
20	29.502	29.548	29.468	29.506	61	64	60	65	78	63	68.7	79	52	.483	.409	.479	.457
21	29.465	29.360	29.314	29.380	63	66	65	70	85	69	74.7	89	52	.482	.[illegible]	.564	.477
22	29.310	29.278	29.232	29.273	65	63	68	73	85	72	76.7	90	60	.5[illegible]0	.[illegible]	.63[illegible]	.474
23	29.341	29.321	29.312	29.328	66	69	69	70	84	75	76.3	86	62	.586	.507	.62[illegible]	.574
24	29.356	29.311	29.282	29.316	69	72	73	73	90	79	80.7	93	68	.655	.542	.73[illegible]	.642
25	29.230	29.190	29.135	29.185	71	70	69	74	76	70	73.3	82	69	.718	.65[illegible]	.69[illegible]	.69[illegible]
26	29.221	29.218	29.289	29.243	66	69	67	68	79	71	72.7	80	66	.612	.574	.60[illegible]	.596
27	29.280	29.215	29.128	29.208	66	74	72	67	84	76	75.7	86	60	.626	.70[illegible]	.73[illegible]	.68[illegible]
28	29.178	29.136	29.252	29.189	73	74	62	76	76	69	74.3	85	68	.744	.81[illegible]	.462	.673
29	29.416	29.491	29.528	29.478	58	58	56	63	71	59	64.3	78	58	.416	.44[illegible]	.40[illegible]	.42[illegible]
30	29.580	29.596	29.512	29.563	55	62	58	66	73	63	67.3	76	50	.287	.40[illegible]	.416	.37[illegible]
31	29.406	29.326	29.304	29.345	60	60	60	66	63	62	63.7	71	60	.438	.47[illegible]	.491	.46[illegible]
Means....	29.398	29.377	29.355	29.377	62.7	65.8	62.5	67.7	76.9	66.9	70.5	93	44	.511	.507	.518	.51[illegible]
Aug. 1	29.242	29.161	29.163	29.189	62	65	65	65	74	68	69.0	79	61	.516	.497	.577	.53[illegible]
2	29.244	29.317	29.368	29.310	60	63	62	63	71	64	66.0	77	56	.478	.469	.524	.492
3	29.466	29.488	29.479	29.478	60	65	64	62	74	67	67.7	77	53	.491	.497	.556	.515
4	29.571	29.547	29.545	29.554	65	68	66	70	83	71	74.7	86	57	.550	.485	.572	.535
5	29.626	29.540	29.525	29.564	66	72	70	71	88	75	78.0	91	63	.572	.589	.666	.609
6	29.541	29.502	29.501	29.515	69	69	66	73	73	68	71.3	82	65	.655	.655	.612	.641
7	29.501	29.467	29.465	29.478	67	73	69	69	84	71	74.7	86	66	.635	.663	.682	.660
8	29.444	29.403	29.388	29.412	64	71	70	77	83	73	77.7	86	62	.556	.597	.693	.615
9	29.396	29.505	29.404	29.435	69	74	69	75	87	73	78.3	90	67	.628	.664	.655	.649
10	29.523	29.530	29.576	29.543	59	65	58	64	75	63	67.3	79	60	.433	.489	.416	.444
11	29.617	29.565	29.498	29.560	58	64	58	60	77	61	66.0	79	53	.456	.422	.443	.440
12	29.397	29.243	29.160	29.267	62	69	69	65	83	75	74.3	86	53	.516	.520	.622	.553
13	29.153	29.178	29.240	29.190	68	68	64	70	73	66	69.7	86	65	.658	.618	.569	.615
14	29.371	29.398	29.430	29.400	63	66	63	65	75	65	68.3	77	56	.549	.519	.549	.539
15	29.507	29.464	29.460	29.477	61	69	62	65	78	66	69.7	80	54	.483	.568	.5[illegible]	.524
16	29.454	29.365	29.342	29.387	60	65	61	63	81	64	69.3	84	56	.478	.400	.497	.459
17	29.260	29.117	29.158	29.178	62	73	70	67	86	77	76.7	93	56	.489	.636	.639	.588
18	29.225	29.184	29.257	29.222	68	71	62	74	89	70	77.7	90	70	.604	.516	.449	.523
19	29.498	29.370	29.397	29.422	58	65	61	60	78	66	68.0	82	56	.456	.443	.479	.456
20	29.452	29.452	29.453	29.452	59	64	60	62	72	62	65.3	75	54	.460	.489	.491	.480
21	29.446	29.388	29.374	29.403	60	74	63	62	76	66	68.0	78	51	.491	.812	.536	.613
22	29.338	29.302	29.286	29.309	62	67	64	65	79	69	71.0	80	52	.516	.501	.529	.515
23	29.223	29.135	29.193	29.184	63	74	67	69	86	74	76.3	89	62	.495	.677	.568	.580
24	29.313	29.349	29.446	29.369	61	61	57	64	77	59	66.7	75	46	.497	.351	.439	.429
25	29.529	29.538	29.502	29.523	53	64	62	55	73	66	64.7	81	53	.376	.476	.502	.451
26	29.494	29.379	29.380	29.419	58	66	62	60	78	66	68.0	87	55	.456	.478	.502	.479
27	29.324	29.219	29.167	29.237	62	82	70	63	83	75	73.7	82	62	.542	.1079	.668	.762
28	29.138	29.166	29.228	29.177	69	75	53	70	80	62	70.7	71	48	.695	.8[illegible]	.284	.593
29	29.335	29.338	29.435	29.369	51	63	48	55	65	50	56.7	68	41	.321	.549	.3[illegible]	.393
30	29.401	29.618	29.552	29.590	44	63	51	47	65	56	56.0	64	53	.249	.549	.3[illegible]	.369
31	29.432	29.285	29.172	29.296	55	59	60	60	60	62	60.7	62	48	.367	.487	.491	.448
Means....	29.402	29.371	29.379	29.384	61.2	68.0	62.8	64.8	77.6	66.8	69.7	93	41	.505	.563	.514	.527

ern and northwestern lakes at Detroit, Michigan.

APOR.			WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. ation=1,000.			Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
										°					
82	.780	.677	N. NE.	E	E	2.0	4.5	2.0	2.7	N. 77 E.	7	9	9	.....	.....
84	.857	.657	SE....	S SW	SW ...	1.5	6.0	6.0	4.0	S. 27 W.	5	6	10	.....	.....
77	.724	.630	SW ...	SW ...	SW ...	1.5	4.5	0.5	2.2	S. 45 W.	7	5	7	.....	.....
70	.848	.823	W. NW	S. SE..	E	1.0	1.5	2.0	0.7	S. 60 E.	10	10	10	.....	.....
55	.902	.819	NE...	S.....	SE.....	1.0	7.0	3.0	3.0	S. 18 E.	10	7	10	.....	.90
69	.802	.773	W. NW	NW...	SW ...	5.0	5.5	1.0	3.7	N. 63 W.	5	6	6	.....	.10
84	.731	.702	W. SW	W. NW	NE....	4.0	9.0	1.5	4.0	N. 76 W.	8	4	8	.....	.....
82	.819	.606	W. NW	W.....	NE....	8.0	3.0	2.0	3.3	N. 29 W.	3	8	10	.....	.....
82	.828	.714	N.....	NW...	NW ...	7.0	6.0	2.0	4.7	N. 24 W.	4	5	6	.....	.30
82	.504	.593	S.....	S.....	S.....	4.0	10.5	10.0	8.2	South ..	8	9	8	.....	.....
75	.751	.671	SW ...	SW ...	W.....	7.0	6.0	1.5	4.7	S. 49 W.	5	7	6	.....	.....
79	.798	.767	N.....	N. NE	NE...	8.0	5.5	2.5	5.0	N. 14 E.	10	10	8	.....	.....
76	.708	.687	NE...	E	SE....	4.0	4.5	5.0	3.3	S. 85 E.	3	5	7	.....	.....
78	.690	.602	SE	E. SE ..	E	2.5	7.5	7.0	5.3	S. 74 E.	5	6	8	.....	.....
83	.884	.812	S. SW	N. NW	N. NW	8.0	16.0	1.0	4.3	N. 49 W.	7	8	10	.....	.....
81	.708	.643	N.....	E	E	4.5	6.0	1.5	3.0	N. 60 E.	0	4	5	.....	.12
74	.713	.597	E	E	E	2.0	1.5	1.0	1.5	East ...	2	4	10	.....	.....
74	.625	.602	E	E	E	2.0	4.0	2.0	2.7	East ...	8	8	10	.....	.....
78	.780	.777	NE....	NE....	NE....	2.3	6.5	0.5	3.0	N. 45 E.	9	9	10	.....	.....
81	.831	.680	N.....	E	E	6.0	8.0	1.0	3.7	N. 57 E.	5	6	7	.....	.....
79	.796	.591	NW...	NW...	NW...	2.5	4.5	1.0	2.6	N. 45 W.	4	5	6	.....	.....
89	.894	.555	N.....	SW ...	SW ...	2.5	3.0	0.7	0.8	West...	2	5	10	.....	.....
77	.724	.653	E	E	E	1.0	3.5	2.0	2.2	East ...	7	8	8	.....	.18
77	.738	.643	W.....	W. NW	W. NW	2.0	6.0	1.5	3.0	N. 72 W.	7	8	10	.....	.....
77	.948	.844	SE....	W. SW	E	3.0	2.0	3.0	1.3	S. 52 E.	10	10	10	.....	.16
78	.802	.759	NE....	E. SE..	SE....	3.5	6.3	1.5	3.3	S. 84 E.	10	3	5	.....	.40
78	.815	.789	E	S.....	S.....	1.0	5.5	2.0	2.7	S. 7 E..	6	4	7	.....	.....
78	.653	.778	SW ...	SW ...	SW ...	8.5	4.0	1.0	4.2	S. 45 W.	8	9	7	.....	.....
78	.819	.790	N. NW	N	S. SW .	12.5	5.5	0.7	5.7	N. 16 W.	4	5	5	.....	.16
78	.723	.559	NW...	E	S.....	5.0	6.7	7.0	1.7	S. 40 E.	4	6	7	.....	.....
78	.884	.767	S.....	S.....	S.....	6.0	7.5	3.0	5.5	South ..	10	10	7	.....	.....
78	.772	.697	.....	.....	.....	....	....	....	0.1	S. 49 E	9.5	6.7	8.0	.....	2.32
82	.843	.757	S	S. SW .	S. SW .	2.7	7.7	11.0	7.0	S. 20 W.	10	8	10	.....	.18
82	.868	.779	NW...	NW...	NW...	7.0	10.0	1.5	6.0	N. 45 W.	4	9	7	.....	.10
82	.841	.773	NE....	NE....	NE....	2.5	6.0	1.5	3.0	N. 45 E.	5	4	5	.....	.....
82	.754	.644	SW ...	SW ...	SW ...	2.0	3.5	0.5	2.0	S. 45 W.	4	5	6	.....	.....
82	.708	.651	SW ...	SW ...	SW ...	2.5	3.5	1.0	2.3	S. 45 W.	4	6	7	.....	.....
82	.895	.836	W.....	W. SW	W. SW	2.0	2.5	1.0	2.0	S. 78 W.	8	10	10	.....	.....
82	.899	.788	W. SW	E. NE	E. SE	2.5	3.5	1.0	0.7	N. 77 E.	9	4	4	.....	.36
82	.854	.741	E	E	E	2.0	5.0	1.5	2.8	East ...	3	4	5	.....	.....
82	.807	.683	SE....	S.....	S.....	2.7	9.0	1.7	4.3	S. 8 E..	5	5	10	.....	.....
82	.723	.669	N.....	E	E	7.0	8.5	3.0	4.7	N 58 E.	8	6	5	.....	.50
82	.825	.720	NE....	E. NE	E	2.0	5.0	2.0	3.0	N. 68 E.	5	6	9	.....	.....
82	.724	.674	SW ...	S. SW .	S.....	3.0	10.0	5.0	5.7	S. 20 W.	7	8	10	.....	.....
82	.891	.850	W.....	N	NE....	1.7	6.0	1.0	2.3	N. 8 W.	9	8	7	.....	.22
82	.890	.793	NE....	NE....	NE....	2.0	5.0	0.7	2.6	N. 45 E.	7	4	3	.....	.....
82	.786	.727	N. NW	E	E. NE.	4.0	3.0	2.5	2.0	N. 4 E.	3	4	5	.....	.....
82	.833	.682	N.....	E	E	1.5	4.0	0.5	1.7	N. 73 E.	5	5	6	.....	.....
82	.689	.647	S.....	S. SW .	W. SW	4.0	7.0	1.5	3.7	S. 21 W.	7	8	8	.....	.....
82	.613	.570	SW ...	W. SW	W.....	3.0	7.0	1.0	3.7	S. 64 W.	5	6	10	.....	.....
82	.735	.693	N.....	W. NW	NW ...	3.0	3.0	1.5	2.0	N. 32 W	8	9	10	.....	.....
82	.884	.779	N.....	E	E	3.5	5.0	2.0	2.7	N. 64 E	7	8	8	.....	.....
82	.838	.876	E. NE.	E	E. SE	2.5	3.5	1.5	2.3	N. 84 E	6	7	8	.....	.....
82	.747	.696	S.....	E	S.....	0.5	4.5	2.0	1.7	S. 61 E	8	6	7	.....	.....
82	.677	.641	SW ...	SW ...	W.....	4.0	5.5	1.5	3.7	S. 53 W	10	8	9	.....	.....
82	.878	.687	N.....	NW...	NW ...	3.5	7.0	2.5	4.0	N. 33 W	6	7	6	.....	.....
82	.736	.749	N.....	E. NE	E	4.5	4.7	1.5	3.0	N. 40 E	5	4	9	.....	.....
82	.786	.722	E	E	E	1.3	4.5	0.5	2.1	East ...	8	8	7	.....	.....
82	.768	.889	N.....	S.....	S.....	1.5	10.5	2.5	3.8	South ..	6	10	10	.....	.....
82	.511	.747	W. SW	W. NW	NW ...	2.0	6.5	2.5	3.3	N. 70 W	10	6	7	.....	.51
82	.856	.830	NW ...	NW ...	NW ...	2.0	6.5	2.0	3.3	N. 45 W	8	10	8	.....	.....
82	.687	.783	NW ...	NW ...	SE....	3.5	7.0	5.0	1.7	N. 45 W	6	5	7	.....	.....
82	.884	.844	S. SW .	SE....	SE....	7.0	2.5	5.0	4.0	S. 13 E	10	10	10	.....	.50
82	.792	.739	.....	.....	.....	....	....	....	0.2	S. 24 W.	6.7	6.7	7.4	.....	2.27

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					o	o	o	o	o	o	o	o	o				
Sept. 1	29.302	29.403	29.405	29.370	53	53	47	57	61	49	55.7	67	48	.350	.297	.297	.315
2	29.446	29.430	29.371	29.416	46	56	54	48	66	58	57.3	70	39	.284	.316	.365	.322
3	29.363	29.346	29.365	29.358	57	60	54	61	62	56	59.7	67	54	.412	.491	.391	.431
4	29.474	29.478	29.382	29.445	49	62	53	50	69	58	59.0	72	43	.335	.462	.386	.394
5	29.355	29.247	29.202	29.268	56	72	67	58	81	69	69.3	86	49	.422	.663	.635	.573
6	29.289	29.383	29.501	29.391	66	56	51	70	65	55	63.3	76	55	.586	.330	.321	.412
7	29.692	29.660	29.657	29.670	49	55	53	52	65	55	57.3	68	45	.306	.300	.376	.328
8	29.673	29.559	29.446	29.559	57	61	60	61	70	62	64.3	75	47	.412	.416	.491	.440
9	29.377	29.310	29.400	29.362	64	60	59	67	76	62	68.3	81	56	.556	.305	.460	.440
10	29.542	29.545	29.538	29.542	43	51	47	47	60	48	51.7	67	45	.225	.255	.310	.263
11	29.541	29.493	29.382	29.472	48	65	54	54	67	57	59.3	69	41	.256	.591	.378	.408
12	29.351	29.296	29.266	29.304	53	60	59	58	71	65	64.7	79	52	.336	.371	.430	.376
13	29.240	29.228	29.394	29.287	59	61	48	63	63	50	58.7	80	42	.447	.510	.309	.422
14	29.593	29.609	29.585	29.596	43	60	51	45	61	55	53.7	78	40	.251	.505	.321	.359
15	29.578	29.460	29.443	29.494	55	65	64	57	76	67	66.7	80	47	.407	.470	.556	.478
16	29.527	29.438	29.501	29.489	66	74	70	68	85	74	75.7	87	66	.612	.691	.679	.661
17	29.586	29.561	29.571	29.573	69	74	70	72	86	74	77.3	91	68	.668	.677	.679	.675
18	29.561	29.512	29.574	29.549	63	76	67	70	80	69	73.0	85	69	.482	.843	.635	.653
19	29.587	29.521	29.460	29.523	61	66	67	64	71	69	68.0	74	62	.497	.572	.633	.564
20	29.366	29.505	29.622	29.498	69	61	54	73	68	56	65.7	83	56	.655	.443	.391	.496
21	29.646	29.605	29.607	29.619	51	58	55	53	68	58	59.7	70	51	.348	.350	.393	.364
22	29.588	29.470	29.578	29.545	51	63	57	55	76	63	64.7	79	48	.321	.402	.399	.374
23	29.770	29.705	29.757	29.744	52	55	51	54	64	55	57.7	72	49	.362	.314	.321	.332
24	29.680	29.535	29.465	29.560	47	63	61	48	76	64	62.7	79	42	.310	.402	.497	.403
25	29.397	29.502	29.615	29.505	57	56	45	61	66	49	58.7	73	48	.412	.316	.247	.320
26	29.762	29.579	29.525	29.622	46	49	42	55	53	43	50.3	61	42	.192	.295	.254	.247
27	29.487	29.441	29.415	29.448	36	57	50	37	67	52	52.0	69	52	.199	.333	.334	.289
28	29.356	29.271	29.229	29.285	49	65	59	50	80	62	64.0	81	44	.345	.417	.460	.404
29	29.204	29.432	29.527	29.388	56	49	39	60	56	42	52.7	74	41	.396	.255	.199	.283
30	29.600	29.631	29.556	29.596	34	45	42	41	51	44	45.3	55	38	.105	.220	.241	.189
Means....	29.498	29.475	29.478	29.483	53.5	60.3	55.0	57.0	68.7	58.0	61.2	91	38	.382	.427	.411	.407
Oct. 1	29.476	29.296	29.182	29.318	40	52	50	41	65	63	56.3	68	33	.235	.216	.189	.213
2	29.068	29.067	29.246	29.127	50	63	50	58	71	56	61.7	79	55	.235	.469	.282	.335
3	29.400	29.367	29.396	29.388	40	48	41	41	54	43	46.0	61	40	.235	.256	.231	.241
4	29.416	29.316	29.219	29.317	36	48	30	37	57	51	48.3	60	30	.199	.217	.348	.255
5	29.231	29.399	29.566	29.399	45	47	41	46	55	43	48.0	58	42	.286	.217	.231	.245
6	29.729	29.798	29.801	29.776	39	46	43	40	56	45	47.0	58	37	.225	.179	.251	.218
7	29.883	29.817	29.791	29.830	38	44	41	39	50	45	44.7	71	34	.216	.209	.205	.210
8	29.681	29.508	29.449	29.566	36	51	49	37	56	51	48.0	63	51	.199	.308	.321	.276
9	29.168	29.089	28.993	29.083	51	55	51	52	58	57	55.7	61	47	.361	.393	.295	.350
10	28.845	28.858	28.919	28.874	50	49	45	55	52	47	51.3	69	46	.295	.348	.273	.292
11	28.997	29.082	29.140	29.073	46	48	47	47	50	49	48.7	53	44	.297	.309	.297	.301
12	29.222	29.300	29.413	29.312	46	51	47	48	56	49	51.0	60	46	.284	.308	.297	.296
13	29.534	29.450	29.491	29.492	43	54	48	44	62	51	52.3	64	43	.264	.312	.296	.291
14	29.530	29.410	29.405	29.448	41	55	49	42	65	52	53.0	69	37	.244	.300	.308	.284
15	29.416	29.389	29.461	29.422	46	54	48	48	67	49	54.7	70	45	.284	.245	.332	.287
16	29.549	29.471	29.464	29.495	47	64	58	49	75	62	62.0	81	40	.297	.449	.429	.392
17	29.425	29.415	29.332	29.391	56	58	54	60	67	56	61.0	79	57	.396	.363	.291	.383
18	29.258	29.358	29.358	29.325	70	62	58	82	66	60	69.3	80	55	.572	.529	.456	.519
19	29.352	29.440	29.449	29.414	65	56	53	79	60	55	64.7	82	59	.431	.396	.376	.401
20	29.459	29.508	29.472	29.480	61	57	55	63	77	58	66.0	80	52	.510	.300	.393	.368
21	29.452	29.309	29.466	29.409	60	58	43	60	70	44	58.0	76	55	.518	.323	.264	.368
22	29.622	29.635	29.742	29.666	43	37	31	41	51	32	41.3	73	41	....	.038	.162	.110
23	29.842	29.822	29.846	29.837	41	37	28	38	50	29	39.0	54	30	....	.051	.142	.064
24	29.859	29.838	29.823	29.840	48	38	29	39	56	31	42.0	59	28	....	....	.137	.137
25	29.785	29.693	29.729	29.736	27	49	46	27	54	50	43.7	61	27	.147	.282	.256	.228
26	29.672	29.684	29.675	29.677	42	51	46	44	56	49	49.7	65	39	.241	.308	.271	.273
27	29.716	29.604	29.636	29.652	43	52	43	44	57	46	49.0	63	37	.264	.322	.238	.275
28	29.630	29.539	29.475	29.548	40	51	49	41	56	52	49.7	61	40	.235	.308	.358	.284
29	29.323	29.366	29.374	29.354	48	54	52	50	59	54	54.3	63	40	.309	.351	.362	.341
30	29.299	29.280	29.304	29.294	49	43	36	50	44	37	43.7	58	36	.335	.264	.199	.266
31	29.440	29.497	29.498	29.478	43	46	42	44	51	44	46.3	53	36	.264	.245	.241	.250
Means....	29.461	29.441	29.455	29.452	46.1	50.9	45.9	47.9	58.8	48.8	51.8	82	27	.303	.328	.283	.305

the northern and northwestern lakes at Detroit, Michigan.

VAPOR.				WIND.								Amount of cloudiness, (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.752	.553	.853	.719	N.....	N.....	N.....	10.0	7.0	2.5	6.5	North..	11	5	7	.....	.....
.850	.495	.756	.700	N.....	S.....	S.....	3.0	7.0	3.0	2.3	South..	4	7	7	.....	.....
.769	.884	.872	.842	SW...	SW...	SW..	4.0	5.0	1.5	3.3	S. 45 W	10	10	10	.....	.....
.927	.653	.698	.756	W....	E....	E.....	1.0	2.0	0.5	0.5	East ...	4	4	5	.....	.20
.876	.627	.896	.800	E.....	S.....	SW...	2.0	6.5	1.0	2.7	S. 9 E..	6	6	10	.....	.....
.799	.535	.743	.692	SW...	NW...	NE ...	4.0	4.5	2.0	1.7	N. 70 W	8	5	4	.....	.....
.794	.487	.869	.717	NE ...	NE ...	NE ...	5.0	8.0	2.5	5.0	N. 45 E.	3	4	6	.....	.22
.769	.570	.884	.741	E.....	E.....	E.....	3.5	8.0	1.5	4.3	East ...	5	5	6	.....	.....
.841	.340	.828	.670	SW...	SW...	W	4.5	4.0	1.5	3.0	S. 51 W	8	10	10	.....	.....
.698	.493	.925	.705	N. NW	E.....	N. NE	4.5	3.0	0.5	1.7	N. 16 E	8	7	3	.....	.04
.613	.893	.812	.773	SW...	SW..	SW..	4.5	8.0	2.0	5.0	S. 45 W	6	7	8	.....	.....
.698	.490	.680	.623	SW...	S.....	S. SW.	4.0	10.5	1.0	5.0	S. 12 W	9	9	9	.....	.....
.776	.886	.856	.839	N.....	N.....	N.....	4.5	2.5	3.5	3.5	North..	10	10	10	.....	.....
.840	.941	.743	.841	N.....	E. NE	E.....	5.0	7.0	4.5	4.3	N. 54 E	4	3	10	.....	.20
.874	.524	.841	.746	E.....	S. SE..	SE....	2.0	9.0	2.5	4.3	S. 37 E.	8	7	10	.....	.....
.895	.574	.810	.760	SW...	SW..	SW..	2.0	7.0	1.0	3.3	S. 45 W	10	6	7	.....	.22
.852	.545	.810	.736	S.....	S.....	S.....	3.0	5.5	0.5	3.0	South..	5	4	0	.....	.28
.658	.824	.896	.793	SW...	W	NE ...	2.5	3.0	2.5	1.0	West...	8	9	10	.....	.....
.833	.754	.896	.828	NE ...	NE ...	NE ...	4.0	5.0	1.0	3.3	N. 45 E.	10	4	5	.....	.26
.807	.647	.872	.775	SW...	NW..	NW..	5.0	12.0	3.0	5.3	N. 64 W	7	8	10	.....	.....
.864	.511	.816	.730	N.....	E.....	NE ...	5.5	3.5	3.0	2.0	N. 36 E.	7	5	6	.....	.....
.743	.448	.718	.636	W.SW	W.NW	N.....	3.5	6.3	2.5	3.3	N. 69 W	7	6	5	.....	.....
.867	.527	.743	.712	N.....	E.....	N.....	4.5	5.0	4.5	3.7	N. 27 E.	4	5	6	.....	.....
.925	.448	.833	.735	S. SE..	SW..	SW...	1.0	4.5	1.0	2.0	S. 38 W	7	7	8	.....	.....
.769	.495	.710	.658	NW...	NW..	NW..	5.5	7.5	4.0	5.3	N. 45 W	6	5	4	.....	.....
.445	.733	.916	.698	NE ...	NE ...	NE ...	3.0	2.5	1.0	2.2	N. 45 E	7	5	7	.....	.....
.903	.503	.861	.756	E.....	SW..	S. SW.	2.5	3.0	0.5	0.7	S. 10 E.	10	4	7	.....	.....
.927	.407	.828	.754	SW...	SW..	SW...	2.0	1.5	1.0	1.6	S. 45 W	6	4	5	.....	.....
.765	.569	.744	.693	N. NE	N. NE	N. NW	8.0	10.5	6.0	7.7	N. 12 E.	9	8	6	.....	.....
.407	.590	.836	.611	NW...	SE....	SE....	3.0	3.5	2.5	1.0	S. 45 E	8	6	6	.....	.....
.784	.598	.818	.733	.....	.....	.....	.....	.....	.....	0.4	N. 13 W	7.1	6.2	6.9	.....	1.82
.912	.351	.329	.531	S.....	S.....	S.....	2.5	10.5	11.0	8.0	South..	4	6	10	.....	.....
.529	.618	.627	.591	SW...	SW...	SW..	10.5	7.0	8.0	10.0	S. 45 W	10	9	10	.....	.....
.912	.613	.833	.786	N. NW	E.....	N.....	4.5	3.0	2.5	2.3	N. 11 E.	10	10	8	.....	.06
.903	.465	.929	.766	N.....	E.....	E.....	2.5	5.5	3.5	3.3	N. 75 E.	5	8	10	.....	.....
.921	.502	.833	.752	NW..	NW..	NW..	6.0	10.0	3.5	6.3	N. 45 W	10	8	5	.....	.64
.910	.399	.840	.716	N.....	E.....	N. NE.	2.5	4.0	1.5	2.7	N. 62 E.	5	3	5	.....	.....
.907	.581	.684	.724	NE ...	NE ...	NE ...	1.0	5.0	3.5	3.0	N. 45 E	4	5	4	.....	.....
.903	.687	.859	.816	E.....	E. NE	E. NE	1.0	7.5	2.5	3.7	N. 70 E	5	6	7	.....	.....
.930	.816	.634	.793	S.....	SW..	SW..	6.5	6.5	13.0	5.0	S. 29 W	10	8	10	.....	.....
.681	.794	.847	.774	SW...	SW..	SW..	7.0	4.0	3.0	4.7	N. 45 W	10	10	10	.....	.60
.923	.856	.853	.877	N. NE	W	N. NW	1.5	1.0	5.5	2.3	N. 22 W	10	10	10	.....	.10
.850	.687	.853	.797	NW..	NE ...	N. NW	4.0	1.5	4.5	2.7	N. 26 W	10	10	10	.....	.06
.918	.561	.790	.756	NW..	W. SW	SW..	2.5	3.7	1.0	2.0	S. 83 W	10	5	10	.....	.....
.914	.487	.794	.732	SW...	SW..	SW..	1.0	3.0	2.5	2.0	S. 45 W	7	6	7	.....	.....
.850	.371	.926	.716	SW...	W	NNW..	3.5	5.5	1.0	3.0	S. 79 W	8	4	4	.....	.....
.853	.518	.772	.714	SW...	SW..	SW..	1.5	5.5	1.0	2.6	S. 45 W	3	5	7	.....	.....
.765	.551	.872	.729	SW...	SW..	SW..	6.0	1.5	2.0	3.0	S. 45 W	6	10	8	.....	.....
.524	.786	.880	.730	SW ..	SW..	SW..	3.0	0.7	2.5	2.0	S. 45 W	7	10	7	.....	.....
.434	.765	.869	.689	SW ..	SW..	SW..	5.5	0.5	1.0	2.0	S. 45 W	6	8	5	.....	.....
.886	.215	.816	.639	S. SW.	S. SW.	S.....	5.5	6.0	3.0	4.7	S. 17 W	4	6	7	.....	.....
1.000	.441	.918	.786	S.....	SW..	N. NW	9.0	2.5	1.5	3.3	S. 13 W	10	10	9	.....	.....
.....	.100	.896	.498	N. NW	W. NW	N. NW	13.0	3.0	3.5	6.3	N. 28 W	6	5	4	.....	.18
.....	.169	.887	.513	NW..	NW..	NW..	4.7	2.0	1.5	2.7	N. 43 W	0	0	0	.....	.....
.....	.....	.788	.788	W. SW	SE....	S. SE..	4.0	2.5	2.0	2.0	S. 13 W	0	0	0	.....	.....
1.000	.674	.716	.797	S.....	E.....	E. SE..	1.5	4.7	2.5	2.7	S. 73 E	8	6	7	.....	.....
.836	.687	.781	.768	SW...	SW..	SW..	1.5	1.0	2.5	1.7	S. 45 W	8	9	10	.....	.....
.918	.692	.767	.792	E.....	E.....	E.....	2.0	6.0	2.0	3.3	East ...	10	8	8	.....	.....
.912	.687	.794	.798	NE ...	E.....	E. NE.	4.0	3.5	4.3	3.7	N. 67 E	10	10	10	.....	.....
.856	.703	.867	.809	E.....	E.....	E.....	3.0	2.5	1.7	2.4	East ...	10	8	10	.....	.....
.927	.918	.903	.916	W	W	W	2.5	3.5	4.5	3.5	West...	10	10	10	.....	.....
.918	.653	.836	.802	NW..	NW..	NW..	1.0	4.5	5.0	3.3	N. 45 W	10	8	7	.....	.48
.850	.577	.805	.739	.....	.....	.....	.....	.....	.....	1.0	S. 54 W.	7.3	7.1	7.4	.....	2.12

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticit, yin U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Nov. 1	29.350	29.109	29.059	29.173	41	51	48	44	63	54	53.7	65	39	.218	.216	.256	.330
2	29.068	29.137	29.197	29.134	49	49	47	51	61	51	54.3	63	50	.321	.190	.270	.260
3	28.991	28.714	28.714	28.806	48	56	48	51	59	53	54.3	63	51	.206	.409	.269	.325
4	29.324	29.454	29.651	29.476	35	38	31	38	42	33	37.7	73	32	.165	.177	.151	.164
5	29.713	29.632	29.670	29.638	30	39	35	32	47	38	39.0	66	30	.141	.134	.165	.148
6	29.682	29.650	29.524	29.619	28	46	38	29	51	41	40.3	53	29	.142	.245	.190	.192
7	29.337	29.217	29.132	29.229	41	44	45	45	55	50	50.0	57	41	.205	.144	.234	.194
8	29.051	29.006	28.921	28.993	45	55	56	51	62	64	59.0	66	47	.220	.349	.343	.301
9	29.132	29.189	29.297	29.206	44	46	41	46	59	51	52.0	77	45	.262	.140	.196	.176
10	29.326	29.333	29.375	29.345	41	42	38	45	55	40	46.7	62	41	.205	.097	.203	.168
11	29.420	29.438	29.493	29.450	32	35	32	35	40	34	36.3	57	33	.142	.139	.155	.145
12	29.597	29.552	29.523	29.557	29	32	30	31	35	34	33.3	43	27	.137	.142	.121	.133
13	29.404	29.374	29.249	29.342	28	40	35	29	47	37	37.7	51	28	.142	.156	.178	.159
14	29.021	29.186	29.479	29.249	36	45	31	37	48	36	40.3	52	35	.190	.260	.116	.192
15	29.561	29.555	29.216	29.444	27	34	36	29	40	41	36.3	44	24	.136	.118	.147	.134
16	29.344	29.513	29.520	29.459	33	32	27	35	37	29	33.7	56	27	.162	.116	.124	.134
17	29.350	29.318	29.382	29.350	33	37	31	35	41	36	37.3	52	28	.162	.168	.116	.149
18	29.479	29.461	29.495	29.478	20	29	23	21	31	24	25.3	43	20	.096	.137	.112	.115
19	29.633	29.609	29.470	29.571	15	34	30	16	36	31	27.7	39	16	.074	.179	.155	.133
20	29.441	29.381	29.450	29.424	30	48	34	32	55	39	42.0	57	30	.144	.243	.131	.173
21	29.501	29.430	29.396	29.443	28	44	37	30	50	39	39.7	52	27	.130	.209	.194	.178
22	29.366	29.347	29.336	29.350	40	46	43	44	51	46	47.0	55	39	.195	.245	.238	.226
23	29.442	29.420	29.402	29.421	40	52	45	44	57	48	49.7	60	42	.195	.322	.260	.259
24	29.290	29.282	29.286	29.286	48	52	51	50	57	56	54.3	62	46	.309	.322	.308	.313
25	29.158	29.063	29.155	29.125	49	59	42	51	53	45	49.7	61	42	.321	.321	.222	.290
26	29.433	29.551	29.604	29.529	36	35	35	37	37	38	37.3	49	36	.199	.178	.165	.181
27	29.577	29.408	29.354	29.446	35	38	36	37	42	39	39.3	44	30	.178	.177	.173	.176
28	29.374	29.377	29.332	29.361	35	36	38	38	40	40	39.3	46	36	.163	.160	.203	.175
29	29.044	28.786	29.110	28.980	37	32	19	38	33	20	30.3	41	19	.207	.168	.092	.156
30	29.354	29.495	29.637	29.495	11	15	14	12	16	16	14.7	25	11	.061	.074	.059	.065
Means....	29.361	29.333	29.347	29.347	34.8	41.1	36.5	37.1	46.7	40.1	41.3	77	11	.184	.197	.183	.188
Dec. 1	29.557	29.469	29.440	29.489	15	23	23	16	24	25	21.7	28	9	.074	.112	.100	.095
2	29.394	29.352	29.556	29.434	23	34	24	25	35	26	28.7	34	24	.100	.183	.106	.130
3	29.477	29.293	29.300	29.357	23	31	28	25	33	29	29.0	61	24	.100	.151	.042	.098
4	29.377	29.198	29.146	29.240	12	22	22	13	24	23	20.0	35	13	.063	.095	.107	.088
5	29.138	29.302	29.252	29.231	21	28	27	22	29	29	26.7	49	20	.101	.142	.124	.122
6	28.878	28.656	28.914	28.819	32	38	32	35	48	35	39.3	52	28	.142	.099	.142	.128
7	29.389	29.375	29.552	29.439	19	20	10	21	21	11	17.7	38	10	.060	.096	.057	.078
8	29.389	29.375	29.552	29.439	11	21	18	12	23	20	18.3	27	9	.061	.090	.076	.076
9	29.665	29.568	29.588	29.607	17	26	29	18	27	31	25.3	32	13	.083	.136	.137	.119
10	29.648	29.541	29.263	29.484	28	28	26	29	29	27	28.3	37	26	.142	.142	.129	.138
11	29.280	29.306	29.293	29.293	25	23	22	26	24	24	24.7	34	23	.123	.112	.095	.110
12	29.310	29.355	29.473	29.379	11	9	6	12	10	7	09.7	32	6	.061	.054	.046	.054
13	29.665	29.596	29.542	29.581	1	10	14	1	11	15	09.0	29	- 1	.045	.057	.071	.058
14	29.415	29.322	29.331	29.356	15	20	20	16	22	21	19.7	31	14	.074	.085	.096	.085
15	29.384	29.379	29.321	29.361	17	20	15	18	21	15	18.0	33	14	.083	.096	.086	.088
16	29.268	29.253	29.199	29.240	19	25	22	20	27	24	23.7	29	14	.092	.112	.085	.096
17	29.019	29.093	29.271	29.128	23	26	25	25	31	30	26.3	32	22	.100	.095	.078	.091
18	29.471	29.623	29.754	29.616	24	25	14	25	27	14	22.0	31	14	.117	.112	.082	.104
19	29.805	29.772	29.568	29.715	6	20	20	6	23	23	17.3	24	4	.057	.074	.074	.068
20	29.385	29.513	29.667	29.522	24	28	24	28	34	30	30.7	40	22	.083	.185	.113	.094
21	29.645	29.392	29.153	29.397	21	25	30	22	31	34	29.0	35	17	.101	.066	.121	.096
22	28.905	29.046	29.180	29.044	32	30	29	41	33	31	35.0	50	30	.064	.132	.137	.111
23	29.559	29.645	29.640	29.615	26	28	24	27	30	26	27.7	40	24	.129	.130	.106	.122
24	29.359	29.267	29.386	29.337	27	35	30	28	37	32	32.3	40	24	.136	.178	.144	.153
25	29.235	28.891	28.930	29.017	39	45	45	40	46	48	44.7	54	30	.225	.286	.261	.257
26	29.399	29.444	29.219	29.354	29	33	35	30	36	40	35.3	54	30	.149	.149	.139	.146
27	28.957	28.796	29.217	28.990	42	48	34	47	51	37	45.0	55	36	.202	.296	.157	.218
28	29.471	29.486	29.524	29.494	30	33	24	31	36	26	31.0	41	25	.155	.149	.116	.137
29	29.698	29.740	29.827	29.755	19	25	18	21	26	19	22.0	32	18	.080	.123	.087	.097
30	29.924	29.964	29.948	29.945	9	20	14	10	21	15	15.3	26	10	.054	.096	.071	.074
31	29.743	29.498	29.281	29.507	17	28	26	18	29	27	24.7	31	11	.083	.142	.129	.118
Means....	29.411	29.371	29.396	29.393	21.0	26.7	23.7	22.2	29.0	25.6	25.6	61	- 1	.102	.125	.107	.111

the northern and northwestern lakes at Detroit, Michigan.

VAPOR.				WIND.							Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation=1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.756	.375	.613	.581	SW...	SW...	SW...	10.5	11.5	4.5	8.7	S. 45 W.	9	8	8	.....	.....
.859	.353	.722	.645	SW...	W	E.....	3.5	7.0	7.0	1.0	S. 45 W.	10	6	10	.....	.....
.790	.819	.667	.759	SE....	S.....	SW...	3.0	14.0	12.5	5.3	S. 25 W.	10	9	10	.....	.....
.719	.661	.800	.727	W	W.NW	W.NW	3.5	5.0	3.0	3.7	N. 74 W.	10	8	6	.....	.90
.794	.413	.719	.642	SW...	SW...	SW...	4.0	8.0	2.0	4.7	S. 45 W.	10	7	5	.....	.....
.887	.653	.738	.759	W.SW	SW...	E. SE.	3.0	2.0	2.0	1.3	S. 35 W.	5	6	8	.....	.....
.684	.333	.646	.554	S.....	S.....	S.....	4.5	8.5	1.5	4.8	South ..	9	8	9	.....	.....
.590	.612	.575	.592	S.....	S.....	S.....	8.0	12.0	19.0	13.0	South ..	10	10	10	.....	.....
.843	.281	.337	.487	SW...	SW...	SW...	5.5	10.7	5.0	7.0	S. 45 W.	10	7	6	.....	.32
.684	.224	.820	.576	SW...	W ...	SW...	4.5	7.0	1.0	3.7	S. 70 W.	7	6	6	.....	.....
.698	.557	.792	.682	SW...	W	W	3.0	6.5	3.0	4.0	S. 80 W.	10	9	10	.....	.....
.788	.698	.617	.701	NW ..	NW...	W.SW	3.5	4.0	2.0	3.0	N. 60 W.	10	10	10	.....	.....
.887	.483	.807	.726	W.SW	NW ..	S.....	3.5	2.5	0.7	1.7	S. 81 W.	8	7	8	.....	.....
.903	.777	.550	.743	W	W.NW	NW...	1.5	4.0	11.0	5.3	N. 54 W.	10	9	10	.....	.....
.883	.476	.567	.642	NW ..	S. SW.	S.....	2.0	11.0	12.0	7.0	S. 15 W.	9	10	10	.....	.....
.797	.527	.775	.700	NW ..	NW...	NW...	3.0	8.0	3.5	5.0	N. 45 W.	8	9	10	.....	.....
.797	.653	.550	.667	W.SW	NW...	NW ..	2.7	5.5	5.0	3.7	N. 55 W.	10	10	10	.....	.....
.855	.788	.868	.837	N. NE.	N. NW	N NW	3.5	5.5	5.5	4.7	N. 12 W.	10	4	8	.....	.....
.829	.802	.893	.841	SW...	SW...	SW...	1.5	3.0	4.5	3.0	S. 45 W.	8	5	10	.....	.....
.794	.561	.547	.634	SW...	SW...	SW...	7.0	4.0	1.5	4.0	S. 45 W.	8	7	9	.....	.....
.782	.581	.816	.726	SW...	S. SW.	S.....	2.5	5.0	0.5	2.3	S. 30 W.	10	10	10	.....	.....
.677	.653	.767	.699	S.....	S.....	S.....	2.5	3.0	1.5	2.3	South ..	10	10	10	.....	.....
.677	.692	.777	.715	SW...	SW...	SW...	2.0	2.5	0.5	1.7	S. 45 W.	10	10	10	.....	.....
.856	.692	.687	.745	S.....	S.....	S.....	13.5	2.0	7.0	7.5	South ..	8	9	10	.....	.92
.859	.798	.762	.806	S.....	S.....	S.....	14.5	13.0	7.0	11.5	South ..	10	10	10	.....	.30
.903	.807	.719	.810	NW...	NW...	NW...	3.5	1.3	1.0	2.0	N. 45 W.	10	10	10	.....	.12
.807	.661	.726	.731	NE....	SW...	SW ..	1.5	5.0	1.5	1.7	S. 45 W.	10	10	10	.....	.....
.719	.645	.820	.728	SW ..	SW...	SW ..	2.0	3.0	4.0	3.0	S. 45 W.	10	10	10	.....	.....
.905	.893	.850	.883	S. SW.	N.....	N. NW	3.0	10.5	10.7	6.0	N. 16 W.	10	10	8	.....	.10
.804	.829	.659	.764	W	W	W	11.0	9.5	6.0	8.8	West...	4	8	10	.....	.20
.794	.610	.706	.703	.....	.....	.....	.....	.....	.....	3.0	S. 48 W.	8.8	8.1	8.7	.....	2.16
.829	.868	.746	.814	S.....	S. SW.	S. SW.	11.5	13.0	14.0	12.7	S. 16 W.	10	10	10	.....	.....
.746	.898	.754	.799	SW...	SW...	SW ..	5.0	9.0	5.0	6.3	S. 45 W.	10	10	8	.....	.02
.746	.800	.887	.811	SW...	SW...	SW ...	10.5	9.0	7.5	9.0	S. 45 W.	10	10	10	.....	.....
.810	.738	.864	.804	W	W.NW	W.NW	4.5	5.5	0.7	3.7	N. 78 W.	8	7	10	.....	.....
.860	.887	.775	.841	SW...	W.SW	S. SW.	4.7	8.0	4.5	5.3	S. 50 W	10	10	10	.....	.....
.698	.292	.698	.563	S.....	W.SW	W	12.5	9.0	17.0	10.0	S. 58 W.	10	8	10	.....	.....
.712	.855	.797	.788	W	W.....	W	8.0	12.5	5.0	8.5	West...	10	8	7	.....	.04
.804	.730	.702	.745	W	W	W	2.5	8.5	10.5	7.2	West...	8	9	10	.....	.....
.840	.883	.788	.837	SW...	SW	SW ...	4.5	4.0	9.0	5.7	S. 45 W.	10	10	10	.....	.....
.887	.887	.880	.885	NW...	N.....	N.....	6.5	3.5	2.0	3.7	N. 23 W.	10	10	10	.....	.....
.876	.868	.738	.827	E. NE.	E. NE.	NE...	3.5	3.0	7.5	4.7	N. 66 E	10	10	10	.....	.....
.804	.791	.769	.788	NE	NE....	NE....	10.5	11.5	9.0	10.3	N. 45 E.	10	10	8	.....	.04
1.000	.797	.823	.873	N.....	NE....	E.....	4.0	5.5	7.5	4.7	N. 56 E.	10	10	10	.....	.....
.829	.721	.855	.802	E. NE	E.....	N. NE.	8.0	7.5	4.0	6.0	N. 68 E.	10	8	10	.....	.....
.840	.855	1.000	.898	N.....	W.NW	W	1.5	3.5	2.0	2.0	N. 62 W.	10	10	10	.....	.....
.850	.761	.738	.783	W	SE....	SE....	3.5	4.0	5.0	2.3	S. 24 E.	10	10	10	.....	.....
.746	.569	.465	.563	W	W	W	2.5	4.0	3.5	3.3	West...	10	10	10	.....	.62
.872	.761	1.000	.878	N. NW	N.NW.	N. NW	5.0	6.5	4.5	5.0	N. 40 W.	10	10	10	.....	.....
1.000	.598	.598	.732	N. NW	S. SE.	E.....	4.0	6.5	5.5	2.3	S. 71 E.	10	10	10	.....	.....
.543	.432	.675	.550	S SW.	W	W	3.0	3.5	2.0	2.3	S. 67 W.	10	10	10	.....	.04
.860	.380	.617	.619	E	E.....	E.....	2.5	4.5	3.0	3.3	East	10	10	10	.....	.....
.250	.703	.788	.580	SW...	SW...	W	7.5	8.7	10.5	8.0	S. 61 W.	10	10	10	.....	.02
.880	.782	.754	.805	W.NW	W	SW...	9.5	4.5	4.0	5.3	N. 87 W.	10	8	10	.....	.....
.883	.807	.794	.828	S.....	S.....	S.....	5.5	4.0	1.0	3.5	South ..	10	8	7	.....	.02
.910	.921	.777	.869	S.....	S.....	S.....	3.0	19.0	14.0	12.0	South ..	10	10	10	.....	.....
.890	.702	.557	.717	SW...	SW...	SW...	8.0	5.0	6.0	6.3	S. 45 W.	8	10	10	.....	.41
.624	.790	.712	.709	SW...	SW...	SW...	7.5	4.5	3.0	5.0	S. 45 W.	10	8	10	.....	.....
.893	.705	.754	.784	NW ..	W	W	5.0	4.5	8.0	5.7	N. 78 W.	7	8	6	.....	.14
.712	.876	.845	.811	W	W	W	7.5	8.0	5.0	7.1	West ..	6	8	6	.....	.....
.791	.855	.823	.823	NW...	N.....	N.....	4.0	4.5	2.0	3.3	N. 16 W.	6	9	10	.....	.....
.840	.887	.880	.869	E	E.....	N.....	5.5	6.5	4.0	4.3	N. 72 E.	10	10	10	.....	.04
.801	.755	.769	.775	.....	.....	.....	.....	.....	.....	2.5	S. 59 W.	9.4	9.3	9.4	.....	1.39

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.							Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Jan. 1	29.706	29.708	29.736	29.717	10	20.5	14	11.5	28	15	18.2	28	9	.051	.094	.071	.049
2	29.685	29.541	29.456	29.561	4	29	12	5	32	13	16.7	32	3	.041	.126	.063	.077
3	29.509	29.406	29.385	29.433	9	33	26	10	37	27	24.7	37	7	.054	.136	.129	.106
4	29.426	29.358	29.285	29.356	23	35	28	25	39	31	31.7	40.5	20	.100	.152	.119	.124
5	29.003	28.917	29.068	28.996	27	31	31	29	36	33	32.7	37	26	.124	.116	.151	.130
6	29.223	29.255	29.325	29.268	26	22	22	27	25	24	25.3	33	25	.129	.084	.095	.103
7	29.405	29.370	29.328	29.368	23	25	12	25	30.5	14	23.2	31	14	.100	.072	.052	.075
8	29.123	29.158	29.231	29.171	22	26	25	24	30	27	27.0	30	9	.095	.095	.112	.101
9	29.161	29.023	28.908	29.031	20	30	23	22	35	25	27.3	36	20.5	.085	.109	.100	.098
10	28.941	28.940	29.022	28.968	14	24	18	16	28	20.5	21.5	28.5	13.5	.059	.083	.070	.071
11	29.181	29.278	27.443	29.301	15	26	12	17	30	13.5	20.2	31	10	.063	.095	.058	.072
12	29.729	29.641	29.399	29.586	-1.5	22	20	- 1	26	22	15.7	24	- 2	.036	.072	.085	.064
13	29.126	29.103	29.228	29.152	22	27	27	23	30	28	27.0	30.5	19	.107	.113	.136	.119
14	29.370	29.303	29.288	29.320	21	25	19	23	29	21	24.3	29	19	.090	.089	.08	.086
15	29.476	29.503	29.455	29.478	8	30	16	9	35.5	18	17.5	35.5	8	.051	.104	.067	.074
16	29.325	29.231	29.229	29.262	21	25	15	23	29	17.5	23.2	29.5	14	.090	.089	.057	.079
17	29.423	29.489	29.705	29.539	4	8	16	5	10	18	11.0	18	3	.041	.040	.067	.049
18	29.781	29.696	29.673	29.717	13	23	2	15	27	3	15.0	27	3	.056	.078	.036	.057
19	29.551	29.365	29.203	29.373	- 8	25	17	- 8	29	18	13.0	29.5	-12	.130	.089	.083	.101
20	29.307	28.958	28.906	29.057	13	19	18	14	21	19	18.0	22	13	.067	.080	.087	.078
21	28.987	29.013	29.129	29.043	21	23	18	22	25	19	22.0	27	18	.101	.100	.087	.096
22	29.326	29.372	29.453	29.384	17	23	21	18	27	23	22.7	27	15.5	.083	.078	.090	.084
23	29.582	29.578	29.681	29.614	18	25	19	20	29	22	23.7	30	18	.076	.089	.069	.078
24	29.790	29.718	29.696	29.735	19	29	22	21	33	24	26.0	34	19	.080	.114	.095	.096
25	29.298	28.853	28.823	28.991	23	28	32	25	31	33	29.7	34.5	21	.100	.119	.168	.129
26	28.978	29.036	29.136	29.050	24	25	21	27	30	23.5	26.8	30	23.5	.095	.078	.084	.086
27	29.388	29.354	29.509	29.384	11	19	15	12.5	22	16.5	17.0	23	10	.054	.089	.069	.064
28	29.597	29.482	29.492	29.524	10.5	18	4	12	21	5	12.7	21	5	.052	.065	.041	.053
29	29.623	29.597	29.617	29.612	- 0	17	3	0.5	20	4	08.2	20.5	- 2	....	.060	.038	.049
30	29.756	29.633	29.475	29.621	-15	24	16	-15	27	18	10.0	27.5	17	.021	.095	.067	.061
31	29.354	29.186	29.080	29.207	9	36	42	10.5	42	45	32.5	45	8	.048	.134	.228	.137
Means....	29.388	29.325	29.334	29.349	13.6	24.9	18.9	15.8	28.8	20.7	21.8	45	-17	.076	.092	.089	.085
Feb. 1	29.249	29.249	29.250	29.249	34	35	24	37	40	27	34.7	48	27	.157	.139	.095	.130
2	28.893	28.583	28.548	28.675	28	33	33	30.5	34	34	32.8	34	23	.125	.175	.175	.158
3	28.763	28.816	28.980	28.853	27	33	26	28	37	28	31.0	36	26	.136	.136	.117	.130
4	29.020	28.843	28.856	28.906	19	31	30.5	20.5	34	32	28.8	34	20	.086	.139	.153	.126
5	29.198	29.327	29.442	29.322	29	35	28	31	40	30	33.7	40	29	.137	.139	.130	.135
6	29.488	29.620	29.643	29.584	22	33.5	18.5	23	38	20.5	27.2	40	20.5	.107	.133	.078	.106
7	29 659	29.574	29.530	29.588	10	45	33.5	11	52	35	32.7	55	9	.067	.207	.172	.145
8	29.403	29.211	29.130	29.248	13	45	35	14.5	50	39	34.5	50	12.5	.061	.234	.152	.149
9	29.118	29.073	29.351	29.181	26	21.5	11.5	27.5	24	13.5	21.7	37	13.5	.123	.086	.050	.086
10	29.747	29.959	30.012	29.906	1	23	3	2	27	4	11.7	27	- 2	.034	.078	.038	.050
11	29.915	29.773	29.758	29.815	15.5	39	35	17	45	37	33.0	46	2	.071	.160	.178	.136
12	29.722	29.632	29.624	29 659	34	43	38.5	38	49	41	42.7	49	35	.144	.199	.201	.181
13	29.422	29.244	29.396	29.354	40	47	46	42	49.5	48	46.5	49.5	37	.221	.290	.284	.265
14	29.602	29.610	29.696	29.636	46	32	27.5	47	34	29.5	38.8	49	28	.297	.155	.127	.193
15	29.668	29.533	29.338	29.513	29	29	29	30.5	32	31	31.2	31	26	.143	.126	.137	.135
16	29.102	29.123	29.234	29.153	40	40	35	42	45	39.5	42.2	45	31.5	.221	.182	.145	.183
17	29.510	29.511	29.499	29.507	31	42	33	34	49	35	39.3	52.5	30	.139	.175	.162	.149
18	29.304	29.215	29.398	29.306	31	49	38	34	57	40	43.7	58	28	.139	.242	.203	.195
19	29.504	29.530	29.218	29.417	28	30	26	30.5	33	27	30.2	39	27	.125	.132	.129	.129
20	29.290	29.290	29.377	29.299	28	32	28	30	37	30.5	32.5	38.5	26	.130	.116	.125	.124
21	29.143	29.252	29.455	29.283	28	30	29.5	30.5	34	32	32.2	34	27.5	.125	.121	.134	.127
22	29.605	29.590	29.469	29.555	27	33	26	30	37	28	31.7	37	25.5	.113	.136	.117	.122
23	29.080	28.827	28.837	28.915	31.5	40	43	33.5	47	46	42.2	47	27	.151	.156	.238	.182
24	29.180	29.287	29.400	29.289	30	32	27	33	36	30	33.0	45.5	28	.132	.129	.113	.125
25	29.458	29.425	29.434	29.439	22.5	33	27	24.5	38	29	30.5	38	23.5	.092	.123	.124	.113
26	29.660	29.702	29.732	29.705	24.5	38	27	26.5	44	29	33.2	48.5	23	.103	.151	.124	.126
27	29.815	29.754	29.659	29.743	22	42	30	24.5	53	31.5	36.3	58	22.5	.089	.123	.150	.121
28	29.472	29.430	29.351	29.418	25	46	32	28	54	36	39.3	54	26	.100	.206	.129	.145
Means....	29.390	29.356	29.380	29.375	26.5	36.1	29.3	28.6	41.1	31.4	33.7	58	- 2	.127	.157	.142	.142

the northern and northwestern lakes at Monroe City, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.701	.162	.823	.562	W	W	W	4	4	2	3.3	West...	2	4	10	.....	.....
.750	.694	.810	.751	W.NW	W	SW .	4	2	2	2.3	N. 89 W.	1	3	2	.....	.....
.791	.619	.880	.763	SW . .	SE....	E.	4	4	4	2.3	S. 35 E.	0	0	3	.....	.....
.746	.636	.685	.689	S	E	E.	25	4	4	9.0	S. 18 E.	9	7	2	.....	.....
.775	.550	.800	.708	E	NE	N	25	12	25	15.7	N. 45 E.	9	10	10	.....	.....
.880	.622	.738	.747	NW . .	NW . .	W	12	12	4	9.0	N. 51 W.	8	10	10	.....	.09
.746	.422	.635	.601	SW . .	S	E.	4	4	2	2.3	S. 7 W .	5	1	0	.....	.....
.738	.569	.761	.689	NE ...	E	W. SW	4	2	4	0.7	N. 33 E.	10	2	10	.....	.....
.721	.539	.746	.668	W	W	W	4	4	4	4.0	West...	1	1	10	.....	.01
.659	.543	.635	.612	W	W	W	4	4	4	4.0	West...	9	10	10	.....	.....
.671	.569	.721	.654	W	N	W	4	4	2	2.7	N. 60 W.	9	5	0	.....	.01
.845	.515	.721	.694	NW . .	N	NE	2	4	35	13.0	N. 38 E.	0	7	10	.....	.....
.864	.675	.883	.807	NE ...	W	W	12	2	2	3.3	N. 27 E.	10	10	10	.....	.26
.730	.556	.712	.666	NE ...	NE ...	NE ...	2	4	12	6.0	N. 45 E.	8	6	10	.....	.....
.784	.499	.682	.655	NW . .	E	E.	2	4	4	2.3	N. 78 E	8	5	10	.....	.08
.739	.556	.597	.628	W	W	W	2	2	35	13.0	West...	10	10	8	.....	.01
.750	.582	.682	.671	W	W	W	25	35	4	21.3	West...	9	6	9	.....	.01
.648	.529	.730	.636	N	N. NE.	N	4	2	2	2.7	N. 6 E..	10	0	0	.....	.01
1.000	.556	.840	.799	NW . .	NW . .	NW . .	2	2	2	2.0	N. 45 W.	0	0	0	.....	.....
.816	.712	.845	.791	NE ...	E	NE ...	4	12	25	12.7	N. 58 E.	5	10	10	.....	.....
.860	.746	.845	.817	NW . .	NW . .	NW . .	4	4	4	4.0	N. 45 W.	10	10	10	.....	.10
.840	.529	.739	.700	W	NW . .	NW . .	4	12	4	6.3	N. 53 W.	4	10	10	.....	.04
.702	.556	.584	.614	W	W	N	2	2	2	1.7	N. 67 W.	9	8	9	.....	.....
.712	.606	.738	.685	NW . .	W.NW	S	2	2	2	1.3	N. 80 W.	10	10	10	.....	.....
.746	.685	.893	.775	E	E	W	25	35	12	16.0	East ...	10	10	10	.....	.12
.644	.465	.669	.593	W.NW	W.NW	W.NW	12	4	12	9.3	N. 67 W.	10	9	10	.....	.25
.711	.584	.748	.681	W.SW	W. SW	W	25	25	12	20.7	S. 71 W.	1	10	10	.....	.....
.706	.570	.750	.675	W	W	W	12	12	4	9.3	West...	10	7	0	.....	.....
.....	.556	.740	.648	W	W	N	4	12	2	5.7	N. 83 W.	0	2	0	.....	.....
1.000	.644	.682	.775	NE	E. SE .	SE....	2	2	2	1.7	S. 81 E	5	3	10	.....	.....
.692	.500	.762	.651	E	SE....	S	2	2	12	4.7	S. 14 E.	3	10	10	.....	.14
.765	.566	.744	.690	.....	.....	.....	....	....	....	2.0	N. 56 W.	6.3	6.3	7.2	.....	1.13
.712	.557	.644	.638	SW . .	SW . .	NW . .	4	2	2	2.0	S. 62 W.	5	5	1	.....	.01
.733	.895	.895	.841	NE ...	NE ...	W.NW	35	4	4	12.7	N. 38 E.	10	10	10	.....	.....
.883	.619	.768	.757	NW . .	NW . .	NW . .	4	2	2	2.7	N. 45 W.	10	8	0	.....	.95
.780	.712	.845	.779	NE ...	NE ...	N	2	12	4	5.7	N. 35 E.	10	10	10	.....	.01
.788	.557	.782	.709	SW . .	SW . .	SW . .	12	4	2	6.0	S. 45 W.	9	8	0	.....	.34
.864	.582	.707	.718	W. SW	W	NE ...	4	4	2	2.0	S. 89 W.	10	1	0	.....	.....
.797	.535	.847	.726	E. NE.	SE ...	E	2	2	4	2.3	S. 85 E.	1	4	0	.....	.....
.730	.646	.636	.671	S	S. SW.	W	2	2	2	1.3	S. 35 W.	3	5	10	.....	.....
.824	.682	.629	.712	NW . .	NW . .	NW . .	4	12	25	13.7	N. 45 W.	10	10	10	.....	.05
.718	.529	.740	.662	W	W	W	4	4	2	3.3	West...	0	0	1	.....	.13
.752	.533	.807	.697	S	S	S	4	12	2	6.0	South..	4	3	9	.....	.....
.628	.572	.781	.660	E	E	E	4	2	4	3.3	East ...	10	9	5	.....	.....
.829	.819	.850	.833	SE....	SW . .	SW . .	2	12	4	5.3	S. 38 W.	10	10	10	.....	.12
.923	.792	.778	.831	NE ...	NE ...	NE ...	4	4	12	6.7	N. 45 E.	10	10	10	.....	.24
.839	.694	.788	.774	NE ...	NE ...	NE ...	4	25	35	21.3	N. 45 E.	10	10	10	.....	.....
.829	.607	.595	.677	W.SW	W.SW	W. SW	25	35	35	31.7	S. 67 W.	1	2	2	.....	.40
.712	.505	.797	.671	W	W	W	4	4	2	3.3	West...	0	2	4	.....	.....
.712	.521	.820	.684	SE....	S. SE .	W	4	2	2	1.7	S. 19 E.	10	1	2	.....	.....
.733	.703	.880	.772	NE ...	NE ...	NE ...	12	4	25	13.7	N. 45 E.	10	10	10	.....	.....
.782	.527	.733	.681	E. NE.	SE....	S	12	2	2	4.3	N. 84 E.	10	10	10	.....	.18
.733	.617	.744	.698	N	N. NW	NW . .	2	12	4	5.7	N. 26 W.	10	10	10	.....	.....
.675	.619	.768	.687	W.NW	E	E	4	2	2	0.7	N. 13 W.	10	9	10	.....	.20
.800	.483	.767	.683	SE....	SE....	NE	2	4	12	4.0	N. 69 E.	10	10	10	.....	.....
.703	.610	.675	.663	W	W.NW	N	4	2	2	2.0	N. 51 W.	9	7	10	.....	.01
.684	.537	.775	.665	NE ...	NE ...	NE ...	4	4	2	3.3	N. 45 E	5	5	5	.....	.....
.703	.522	.775	.667	W	W	S	2	2	4	2.0	S. 45 W.	4	1	0	.....	.....
.680	.306	.843	610	E	E	E.	2	2	2	2.0	East ...	0	1	0	.....	.....
.655	.493	.610	.586	SE....	SE....	S	2	2	2	1.7	S. 34 E	6	5	5	.....	.....
.757	.690	.760	.706	.....	.....	.....	....	....	....	1.2	N. 8 W .	7.0	6.3	5.8	.....	2.64

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
March 1	29.145	28.932	28.836	28.971	37	49	53	39	55	55	49.7	55.5	32	.194	.269	.376	.280
2	29.102	29.246	29.425	29.258	28	48	22	32	55	24	37.0	55	24	.108	.243	.095	.149
3	29.435	29.231	29.143	29.270	20.5	21	22	23	23.5	24.5	23.3	24	18	.081	.084	.101	.089
4	29.281	29.362	29.478	29.374	20.5	30	27	21.5	33	30	28.2	33	19.5	.098	.132	.113	.114
5	29.731	29.749	29.763	29.748	22	32	21	24	37	23	28.0	37	21.5	.095	.116	.096	.100
6	29.765	29.642	29.428	29.612	32	28	29	24	32	30	28.7	32.5	22	.095	.108	.149	.117
7	29.355	29.547	29.697	29.533	27	33	25	29	38	27.5	31.5	40	26	.124	.123	.106	.118
8	29.773	29.755	29.627	29.718	22.5	33	27	24.5	39	28	30.5	39	19	.097	.110	.136	.114
9	29.602	29.547	29.467	29.539	27	39	30	29	46	32.5	35.8	46.5	27	.124	.147	.138	.136
10	29.120	28.922	29.109	29.050	35.5	40	43	37.5	45	47	49.8	47	30	.182	.182	.225	.196
11	29.492	29.492	29.424	29.469	33	35.5	31	36	39	33	36.0	47	30	.149	.162	.151	.154
12	29.265	29.292	29.382	29.313	28	27	31	30	42	34	35.3	42	26.5	.130	.155	.139	.141
13	29.330	29.368	29.571	29.423	30	26	8	32.5	28	10	23.5	34	8	.138	.117	.040	.098
14	29.717	29.699	29.754	29.723	8	19	10	9	23	12	14.7	23	5	.051	.058	.046	.052
15	29.815	29.759	29.715	29.763	11	34	21	12	37	24	24.3	38	7	.061	.157	.079	.099
16	29.668	29.343	29.150	29.387	24	29	26	26.5	33	28	29.2	33	22	.103	.114	.117	.111
17	29.221	29.338	29.487	29.349	23.5	22	10	26.5	27	12	21.8	27	12	.092	.061	.046	.066
18	29.562	29.450	29.479	29.497	11	33	21	13	38	23	24.7	40	9	.049	.123	.09	.087
19	29.586	29.613	29.699	29.633	15	32	26	18	40	29	29.0	41	10	.052	.077	.106	.078
20	29.672	29.638	29.590	29.593	29	34	32	31.5	39	36	35.5	39	24.5	.134	.131	.129	.131
21	29.362	29.288	29.260	29.303	32	33	33.5	33.5	35	35	34.5	35	31	.162	.162	.172	.165
22	29.370	29.374	29.536	29.427	35	37	33	36.5	41	35	37.1	41	33	.184	.168	.162	.171
23	29.560	29.516	29.486	29.521	32	42	33.5	34	46	36	38.7	46	32	.155	.215	.159	.176
24	29.400	29.260	29.399	29.353	34	35	36	36	39.5	38	37.8	40	31	.170	.145	.186	.167
25	29.582	29.619	29.692	29.631	28	34	27	31	42	30.5	34.5	42	29.5	.119	.092	.107	.106
26	29.678	29.540	29.263	29.494	25	27	28	29	30	29	29.3	30	26.5	.089	.113	.142	.115
27	29.163	29.210	29.270	29.214	25	29	28	26.5	32	29	29.2	32	24	.118	.126	.130	.125
28	29.371	29.382	29.397	29.383	20	33	31	22	39	33	31.3	41	16	.085	.110	.151	.115
29	29.458	29.366	29.359	29.394	28	39	31	30	47	36	37.7	47	24	.139	.134	.116	.127
30	29.352	29.265	29.283	29.300	28	45	36	31	53	40	41.3	58	28	.119	.194	.169	.158
31	29.276	29.102	28.999	29.126	33	45	41	37	52	44	44.3	59	32	.136	.207	.218	.187
Means..	29.458	29.408	29.425	29.430	25.6	33.9	28.1	27.9	38.9	30.5	32.4	59	5	.117	.140	.135	.131
April 1	28.952	28.997	29.107	29.019	33.5	44	35	35.5	48	38	40.5	49	34	.162	.236	.165	.188
2	29.342	29.406	29.503	29.417	34	44	35	37	51	40	42.7	54	34	.157	.196	.139	.164
3	29.564	29.446	29.305	29.438	34	45	45	37	53	50	46.7	55	32	.157	.194	.234	.195
4	29.149	29.106	29.101	29.119	49	54	43	56	59	45.5	53.5	62	45.5	.255	.351	.245	.284
5	29.037	29.006	29.194	29.079	33.5	34	31	37	37	33.5	35.8	45	33	.146	.157	.145	.149
6	29.330	29.225	29.178	29.244	26.5	42	38.5	29.5	52	44.5	42.0	54	26	.107	.136	.155	.133
7	29.224	29.263	29.330	29.272	42	47	43	49	57	47	51.0	62	41	.175	.191	.212	.193
8	29.246	29.415	29.538	29.400	40	51	39	44	57	42	47.7	57	39	.195	.245	.199	.230
9	29.638	29.513	29.420	29.524	34.5	46	37	37	52	41	43.3	53	32.5	.167	.232	.166	.188
10	29.243	29.106	29.200	29.183	39	37	32.5	43	43	40.5	42.2	43	39	.186	.155	.207	.183
11	29.376	29.384	29.356	29.372	30	45	36	32.5	52	40	41.5	52.5	30	.138	.207	.16	.168
12	29.336	29.282	29.248	29.289	29	53	43	32	65	49	48.7	68	28	.126	.244	.199	.190
13	29.346	29.352	29.392	29.363	35	55	44	38	68	48	51.3	69	35	.165	.261	.236	.221
14	29.410	29.300	29.259	29.323	49	59	52	54	75.5	57	62.2	75.5	46	.292	.380	.322	.331
15	29.138	29.045	29.068	29.084	54	56	54	57.5	62	57.5	59.0	62	55	.371	.369	.364	.375
16	29.053	29.121	29.284	29.153	54	52	45	56	57	48	53.7	57	48	.391	.322	.289	.334
17	29.328	29.472	29.544	29.448	41.5	49	49	47	64	61	57.3	66	42	.190	.150	.190	.177
18	29.723	29.697	29.638	29.686	34	48.5	41	39	56	45.5	46.8	57	36	.131	.242	.198	.190
19	29.533	29.400	29.275	29.403	42.5	50	46	46	59	50	51.7	62.5	42	.226	.242	.25	.242
20	29.155	29.055	29.172	29.127	50	55	50	56	68	53	59.0	68	48	.282	.261	.321	.288
21	29.265	29.192	29.142	29.200	38.5	50	49	43	64	52.5	53.2	66	40.5	.174	.176	.302	.217
22	28.769	29.134	29.268	29.057	42	49	38	44	45	41	43.3	52.5	36	.241	.182	.190	.204
23	29.438	29.496	29.534	29.486	34	40	37	35.5	44	39	39.5	44	34	.176	.195	.194	.188
24	29.496	29.481	29.505	29.494	37	41	41	39	47	43	43.0	46	36	.194	.179	.231	.201
25	29.536	29.502	29.480	29.506	42	50	46.5	44	57	49	50.0	59	34	.241	.248	.284	.264
26	29.348	29.165	29.118	29.210	43.5	53	51	49	63	57	56.3	67	42	.211	.270	.295	.259
27	29.471	29.460	29.465	29.465	32	50	37	34	57	69	43.3	57	33	.155	.268	.194	.206
28	29.526	29.496	29.331	29.451	39	41	38	47	50	42	45.7	57	35	.134	.139	.177	.150
29	29.218	29.095	29.101	29.138	48	50	60	51	63	64	59.3	67	42	.286	.189	.465	.317
30	29.118	29.144	29.144	29.135	55	54	54	57.5	67	55	59.8	68	54	.400	.345	.404	.383
Means....	29.310	29.292	29.307	29.303	36.5	47.8	43.2	43.6	56.4	47.1	49.0	75.5	26	.208	.228	.228	.225

the northern and northwestern lakes at Monroe City, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											o					
.816	.620	.869	.768	SE....	S. SW.	SW..	2	4	4	2.7	S. 19 W.	10	9	10	.....	.02
.594	.561	.738	.664	W.SW	W	N	35	2	4	10.7	S. 73 W.	9	5	3	.....	.....
.663	.669	.800	.711	NE ..	NE ...	NE ...	35	25	2	20.3	N. 45 E	10	10	10	.....	.....
.857	.703	.675	.745	W	W.NW	W.NW	2	4	4	3.3	N.72 W.	9	4	8	.....	.06
.738	.527	.730	.665	W	W	W	4	2	2	2.7	West...	7	1	5	.....	.....
.738	.594	.890	.741	NE ...	NE ...	NE ...	4	35	4	14.3	N. 45 E	10	10	10	.....	.....
.775	.537	.707	.673	N	W. ...	N	4	2	2	2.7	N.10 W.	5	4	3	.....	.12
.742	.463	.883	.696	NE ...	NE ...	NE ...	2	4	12	6.0	N. 45 E.	8	4	4	.....	.....
.775	.471	.748	.665	E	E	E	2	2	12	5.3	East ...	6	2	9	.....	.....
.809	.607	.698	.705	E. SE	S	W	4	4	35	10.7	S. 80 W.	10	10	10	.....	.....
.705	.682	.800	.729	W	NE ...	NE ...	4	4	4	2.0	N. 15 E	10	9	10	.....	.14
.782	.577	.712	.690	NE ...	S. SE	N.NE .	25	4	2	9.0	N. 52 E	10	9	10	.....	.20
.748	.768	.582	.699	S. SW.	SW...	W	2	45	12	18.7	S. 53 W.	10	3	1	.....	.01
.784	.467	.610	.620	W	W	W	12	4	4	6.7	West...	5	3	0	.....	.....
.804	.712	.610	.709	S. SW.	SW .	S	2	4	2	2.3	S. 28 W.	1	1	1	.....	.....
.703	.606	.768	.692	NE ...	NE ...	NE ...	35	25	4	21.3	N. 45 E.	9	9	10	.....	.....
.639	.415	.610	.555	W	W	W	35	35	25	31.7	West...	9	5	0	.....	.16
.623	.537	.730	.630	SW ..	SW ..	SW ..	4	4	2	3.3	S. 45 W.	7	2	0	.....	.....
.525	.312	.665	.501	NW ..	E	E	2	2	4	1.7	N. 74 E	0	1	1	.....	.....
.744	.547	.610	.634	E	E. NE	E	12	25	25	20.3	N. 81 E.	2	3	10	.....	.....
.841	.797	.847	.828	NE ...	NE ...	NE ...	25	25	25	25.0	N. 45 E.	10	10	10	.....	.....
.853	.653	.797	.768	N	N	N	2	2	4	2.7	North ..	10	10	10	.....	.22
.792	.691	.753	.745	E.NE	NE ...	E	2	4	2	2.3	N. 59 E	10	5	10	.....	.....
.802	.595	.811	.736	E	SE....	W.NW	2	2	25	7.0	N.67 W.	10	10	10	.....	.11
.685	.343	.628	.552	NW ..	NW ..	NE ...	12	4	2	5.3	N.38 W.	9	3	0	.....	.12
.556	.675	.887	.706	NE ...	NE ...	NE ...	12	35	25	24.0	N. 45 E.	9	10	10	.....	.....
.818	.694	.782	.765	NW ..	NW ..	NW ..	4	2	4	3.3	N.45 W.	10	10	10	.....	.12
.721	.463	.800	.661	NW ..	NW ..	NW ..	4	2	2	2.6	N. 45 W.	1	1	3	.....	.02
.782	.413	.550	.582	NW ..	W	W	2	25	25	17.0	N.88 W.	1	5	0	.....	.....
.685	.483	.645	.604	W	W	W.NW	4	12	2	5.7	N.87 W.	0	0	0	.....	.....
.619	.515	.756	.637	W.....	SE....	W	2	2	12	4.3	S. 84 W.	0	10	10	.....	.....
.733	.571	.732	.679	.....	.....	.....	....	....	....	2.8	N. 8 W	3.8	5.8	6.1	.....	1.20
.797	.704	.719	.740	W	W	W	35	35	4	24.7	West...	9	5	9	.....	.26
.712	.525	.557	.598	W	W	W	4	24	2	10.0	West...	0	0	1	.....	.....
.712	.483	.646	.614	SE....	SE....	SE....	2	4	4	3.3	S. 45 E.	9	10	10	.....	.....
.569	.703	.803	.692	SW ..	SW ..	SW ..	12	25	12	16.3	S. 45 W.	8	10	10	.....	.....
.665	.712	.756	.711	W	W.NW	NW ..	12	25	35	23.0	N.60 W.	10	10	5	.....	.19
.670	.350	.527	.516	SW ..	SW ..	SW ..	4	35	12	17.0	S. 45 W.	0	3	0	.....	.02
.505	.411	.631	.516	SW ..	SW .	SE....	25	2	2	9.0	S. 40 W.	8	4	2	.....	.....
.677	.634	.744	.685	S	S	S	4	2	2	2.7	South ..	7	5	0	.....	.....
.759	.598	.653	.670	E.NE .	NE ...	E	4	4	4	3.7	N. 65 E.	0	4	4	.....	.....
.669	.577	.822	.689	SE....	E	W	4	4	4	1.3	S. 45 E.	10	10	5	.....	.....
.748	.535	.645	.643	N	NE ...	N.....	4	2	2	2.7	N. 10 E.	5	0	0	.....	.34
.694	.395	.572	.554	S	SE ...	W	2	4	2	1.7	S. 9 E..	0	0	0	.....	.....
.719	.381	.704	.601	NW ..	E.NE .	E. NE.	2	12	2	4.3	N. 60 E.	0	4	4	.....	.....
.674	.318	.692	.561	S	S	S	2	25	2	9.7	South ..	5	5	9	.....	.....
.784	.665	.814	.754	S	S	S	2	4	4	3.3	South ..	10	10	9	.....	.07
.872	.692	.777	.780	N	N	N.....	4	35	2	13.7	North ..	10	9	0	.....	.50
.589	.251	.353	.398	N	N	N.....	12	4	4	6.7	North ..	0	0	0	.....	.....
.547	.540	.650	.579	NW ..	NE ...	NE....	2	4	4	3.0	N. 28 E	2	5	5	.....	.....
.729	.484	.716	.643	E	E	E	2	4	2	2.7	East ...	10	6	5	.....	.....
.627	.381	.798	.602	SW ..	SW ..	W	4	45	4	17.3	S. 48 W.	3	3	0	.....	.....
.627	.295	.763	.562	NW ..	NW ..	SE....	4	4	2	2.0	N.45 W.	5	5	10	.....	.....
.836	.607	.738	.727	NE ...	N	NE....	4	2	12	6.0	N. 41 E.	10	10	10	.....	.78
.849	.677	.816	.781	NE ...	E	E	4	2	2	2.3	N. 69 E.	10	9	10	.....	.20
.816	.554	.833	.734	NE ...	SE....	SE....	4	12	12	8.0	S. 53 E.	10	10	10	.....	.03
.836	.577	.816	.743	W	W	W	2	4	2	2.7	West...	1	5	2	.....	.06
.607	.470	.634	.570	S	S	S	12	35	25	24.0	South ..	2	3	10	.....	.....
.792	.577	.816	.728	NW ..	W	SW ..	25	4	25	13.1	West...	3	4	4	.....	.14
.413	.386	.661	.487	S	E	NE	12	12	35	13.0	N. 71 E	0	0	5	.....	.....
.790	.329	.780	.633	SE....	S	SW ..	2	12	4	5.7	S. 5 W	10	2	10	.....	.....
.844	.371	.934	.716	SW ..	W	N.....	4	12	25	9.0	N.33 W.	1	5	10	.....	.....
.704	.506	.712	.641	.....	.....	.....	....	....	....	2.9	S. 64 W.	5.6	5.5	5.3	.....	2.59

Reductions of the monthly meteorological register of the surrey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
May 1	29.184	29.197	29.275	29.219	41	48	44.5	43	63	48	51.3	62	43	.231	.137	.247	.205
2	29.426	29.555	29.610	29.564	31	35.5	37	34	47	38	39.7	51	33	.139	.056	.207	.135
3	29.686	29.655	29.556	29.632	31	41	40	33	49	33	41.7	49	30	.151	.153	.208	.171
4	29.313	29.224	29.172	29.236	49	57.5	55	52	64	58	58.0	68	43	.308	.387	.393	.363
5	29.213	29.237	29.298	29.249	43.5	41	41	46	49	43	46.0	56	43	.250	.153	.231	.213
6	29.267	29.226	29.264	29.252	55	53	53	58	65	56	59.7	65	44	.393	.244	.363	.333
7	29.326	29.265	29.298	29.296	37	42.5	40	39	49	42	43.3	49	37	.194	.187	.221	.201
8	29.268	29.146	29.129	29.181	40	50	45	43	56	48	49.0	56	36	.208	.282	.260	.250
9	29.132	29.086	29.103	29.107	39	53	51	43	63	54	53.3	66	34	.186	.270	.335	.264
10	29.200	29.210	29.245	29.218	45	52	51	47	63	53	54.3	63.5	45	.273	.243	.348	.288
11	29.348	29.356	29.389	29.364	41	59	52	45	67	56	56.0	67	38	.205	.393	.335	.311
12	29.485	29.455	29.395	29.445	51	52	44	55	63	48	55.3	67	39	.321	.243	.229	.264
13	29.096	28.971	28.985	29.017	50	58	54	53	64	58	58.3	70	41	.231	.403	.365	.333
14	28.992	29.049	29.044	29.028	44.5	43	46	47	49	49.5	48.5	58	46	.261	.199	.265	.242
15	28.954	29.014	29.167	29.045	44	51	44	45	59	49	51.0	59	43	.275	.269	.223	.256
16	29.186	29.185	29.230	29.200	42	55	46.5	45	61	49	51.7	61	38.5	.228	.354	.284	.289
17	29.298	29.403	29.550	29.417	44	47.5	47	46	57	48	50.3	59	44	.262	.304	.310	.292
18	29.621	29.592	29.546	29.586	42	53	55	44	67	58	56.3	67	36	.241	.217	.393	.284
19	29.417	29.272	29.240	29.310	52	45	44	59	51	46	52.0	60	44	.296	.220	.262	.252
20	29.263	29.247	29.197	29.236	47.5	53	47	49.5	58	49	52.2	59	45	.303	.336	.297	.312
21	28.936	28.801	28.730	28.822	48	50	51	49	55	53	52.3	57	47.5	.322	.295	.348	.322
22	28.818	28.916	28.958	28.894	43	44	41	45	47	44	45.3	55	41	.251	.249	.218	.239
23	29.089	29.174	29.193	29.152	43	47	47	45	53	51	49.7	55	40	.251	.257	.270	.259
24	29.258	29.202	29.177	29.212	45	56	51	48	69	55	57.3	69	40	.260	.276	.321	.286
25	29.061	29.031	29.098	29.063	47	51	49	52	59	50	53.7	61	48.5	.257	.269	.335	.287
26	29.197	29.252	29.312	29.254	45	57	57	49	69	60	59.3	69	44	.247	.306	.246	.266
27	29.447	29.400	29.407	29.418	49	47.5	49.5	53	59	52	54.7	60	40	.295	.309	.321	.308
28	29.250	29.207	29.182	29.213	48	53	51	49	63	54	55.3	67	48	.322	.270	.335	.309
29	29.202	29.294	29.314	29.270	58.5	57	51	63	67	55	61.7	67	51	.431	.333	.321	.362
30	29.397	29.396	29.434	29.409	51	60	56.5	56	72	59	62.3	72	50	.308	.358	.424	.363
31	29.542	29.532	29.494	29.523	45	61	54	49	71	56	58.7	73	41	.260	.403	.391	.351
Means....	29.260	29.246	29.258	29.255	44.9	50.8	48.2	47.9	59.6	51.1	52.9	73	30	.263	.267	.300	.277
June 1	29.407	29.264	29.112	29.261	54	60	55	57	67	58	60.7	68	41	.378	.425	.393	.399
2	28.975	28.910	28.910	28.932	65	69	62	67.5	82	68	72.5	82	58	.584	.534	.476	.531
3	28.963	29.042	29.151	29.052	56	56.5	56	59	66	59	61.3	67	57	.409	.331	.419	.386
4	29.232	29.228	29.283	29.248	56	65	64	58	79	69	68.7	79	53	.422	.431	.529	.461
5	29.371	29.365	29.303	29.346	59	71	64	63	80	67	70.0	80	56	.447	.637	.556	.547
6	29.248	29.217	29.223	29.229	68	70	67	72	84	72	73.3	88	66	.631	.545	.585	.590
7	29.276	29.295	29.323	29.298	69	76	69	72	85	73	76.7	87	61	.668	.775	.635	.699
8	29.411	29.428	29.487	29.409	63.5	67	66	65	78	69	70.7	81	63	.566	.514	.599	.560
9	29.481	29.473	29.463	29.472	60	67	65	66	78	68	70.7	81	56	.438	.514	.577	.510
10	25.445	29.400	29.411	29.419	60	64	62	64	74	66	68.0	75	55	.465	.462	.502	.476
11	29.391	29.338	29.315	29.448	62.5	70	68	68.5	79	72	73.2	83	63	.485	.612	.631	.576
12	29.368	29.344	29.398	29.370	60	74	64	69	85	67	73.7	87	67	.398	.691	.556	.548
13	29.443	29.438	29.433	29.438	66	72	68	68	83	71	74.0	84	61	.612	.636	.644	.631
14	29.411	29.352	29.332	29.365	64	65	70	69	73	74	72.0	79	63	.529	.510	.679	.573
15	29.291	29.197	29.238	29.242	69	73	69	72	84	74	76.7	84	67	.668	.663	.641	.657
16	29.325	29.394	29.403	29.374	67	78	70.5	70	90	76	78.7	90	67	.622	.796	.671	.696
17	29.335	29.282	29.315	29.311	66	81	70	70	91	71	77.3	92.5	63	.586	.921	.720	.742
18	29.406	29.585	29.561	29.517	52	62	60.5	69	72	64	68.3	74	63	.163	.422	.480	.355
19	29.604	29.558	29.523	29.562	60	67	61	65	79	65	69.7	80	51	.451	.501	.483	.478
20	29.534	29.523	29.491	29.516	57	78	66	61	81	70	70.7	83	56	.412	.918	.586	.639
21	29.444	29.503	29.468	29.472	63	69	66.5	67	82	70	73.0	81	56	.522	.534	.603	.553
22	29.468	29.417	29.418	29.434	67	74	70	71	88	74	77.7	90	57	.608	.650	.679	.646
23	29.360	29.347	29.295	29.334	70	75	71	75	89	76	80.0	90	67	.666	.678	.691	.678
24	29.243	29.180	29.155	29.193	69	71	71	72	84	76	77.3	87	67	.668	.583	.691	.647
25	29.130	29.192	29.230	29.184	68	70	71	72	80	76	76.0	82	70	.631	.598	.691	.640
26	29.281	29.384	29.236	29.300	62	75	71	66	87	76.5	76.5	90	59	.502	.705	.684	.629
27	29.260	29.214	29.338	29.271	65	70	66	69	81	71	73.7	87	67	.564	.585	.572	.574
28	29.500	29.510	29.632	29.547	61	68	62	66	79.5	66	70.5	80	62	.470	.530	.502	.501
29	29.543	29.426	29.340	29.436	59	63	69	64	89	78	77.0	91	59	.433	.228	.588	.415
30	29.240	26.114	29.197	29.184	71	79	75	72	92	83	82.3	93	67	.745	.814	.760	.773
Means....	29.346	29.331	29.333	29.337	63.0	70.0	66.3	67.3	81.4	70.6	73.1	93	41	.595	.591	.595	.570

he northern and northwestern lakes at Monroe City, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.633	.238	.740	.604	N.	NW.	NW.	25	12	25	19.0	N. 28 W.	4	2	2	.....	.13
.712	.178	.905	.598	NW.	NW.	NE.	4	4	4	3.0	N. 18 W.	2	1	0	.....	.....
.800	.439	.750	.663	NE.	NE.	E.	12	25	35	22.3	N. 67 E.	1	4	8	.....	.....
.794	.650	.816	.753	SE.	SW.	SW.	4	12	2	5.0	S. 31 W.	4	10	10	.....	.....
.805	.439	.833	.692	W.	W.	W.	2	25	12	13.0	West.	9	5	4	.....	.76
.816	.395	.809	.673	W.	W.	W.	2	4	4	3.3	West.	7	5	9	.....	.10
.816	.538	.829	.728	NW.	NW.	NW.	2	2	2	2.0	N. 45 W.	8	6	4	.....	.....
.750	.627	.777	.718	N.	N.	N.	12	2	2	5.3	North.	3	0	0	.....	.....
.669	.470	.802	.647	W.	W.	W.	2	2	12	5.3	West.	2	3	10	.....	.....
.847	.422	.864	.711	W.	W.	W.	4	2	4	3.3	West.	1	2	3	.....	.02
.684	.595	.747	.675	W.	W.	N.	2	12	12	6.3	N. 51 W.	1	2	0	.....	.....
.743	.422	.670	.612	N.	N. NE.	NE.	2	12	25	12.7	N. 36 E.	0	7	8	.....	.....
.798	.675	.756	.743	E.	SE.	S.	12	4	2	5.0	S. 71 E.	7	5	5	.....	.72
.809	.572	.748	.710	SW.	W.	W.SW.	12	2	4	6.0	S. 56 W.	10	10	10	.....	.....
.920	.537	.638	.698	W.	W.	W.	4	4	2	3.3	West.	10	7	6	.....	.48
.672	.659	.817	.716	SW.	S.	SW.	2	2	2	1.7	S. 29 W.	0	7	5	.....	.10
.843	.438	.925	.735	W.	N.	N. NE.	12	2	2	4.0	N. 71 W.	6	7	5	.....	.04
.836	.329	.816	.660	NE.	NE.	SE.	2	4	2	2.0	N. 62 E.	0	4	5	.....	.....
.592	.590	.843	.675	E.	NE.	NE.	12	12	12	11.3	N. 60 E.	5	10	10	.....	.....
.854	.698	.853	.802	NE.	NE.	NE.	2	4	12	6.0	N. 45 E.	8	6	5	.....	.29
.926	.681	.864	.824	NE.	E. NE.	E.	35	25	12	23.0	N. 60 E.	10	10	10	.....	.68
.840	.772	.756	.789	N.	N.	N.	12	4	12	9.3	North.	10	10	10	.....	1.22
.840	.660	.722	.741	W.	W.	W.	25	4	2	10.3	West.	5	2	1	.....	.25
.777	.391	.743	.637	SW.	SW.	SW.	2	12	2	5.3	S. 45 W.	1	6	1	.....	.....
.660	.537	.927	.708	S.	SW.	NW.	4	4	4	2.3	S. 55 W.	5	10	2	.....	.....
.710	.432	.822	.655	N.	N.	N.	2	4	4	3.3	North.	2	1	3	.....	.09
.733	.889	.829	.816	NE.	NE.	NE.	4	4	12	6.7	N. 45 E.	7	7	10	.....	.....
.926	.470	.802	.733	NE.	E.	SE.	25	2	12	10.0	N. 71 E.	10	5	3	.....	.43
.749	.503	.743	.665	SW.	SW.	W.	12	25	4	13.3	S. 49 W.	6	4	4	.....	.01
.687	.457	.848	.664	NW.	NW.	N.	2	2	4	2.3	N. 24 W.	3	1	1	.....	.....
.777	.532	.872	.727	NE.	SE.	SE.	2	2	4	2.0	S. 62 E.	0	0	0	.....	.....
.781	.524	.902	.702	..	.....	.....	....	....	....	2.2	N. 1 E.	4.7	5.1	5.0	.....	5.32
.812	.642	.816	.757	NE.	NE.	NE.	4	12	25	13.7	N. 45 E.	4	7	10	.....	.61
.868	.489	.695	.684	S.	SW.	W.	12	12	4	8.0	S. 32 W.	9	3	7	.....	.20
.819	.518	.819	.719	W.	W.	W.	12	25	2	13.0	West.	7	4	10	.....	.....
.876	.434	.747	.686	SW.	SW.	SW.	2	2	2	2.0	S. 45 W.	6	1	1	.....	.12
.776	.623	.841	.747	SE.	NE.	NE.	2	4	4	3.0	N. 28 E.	0	1	1	.....	.....
.804	.468	.758	.677	S.	W.	W.	2	2	4	2.3	S. 73 W.	0	10	10	.....	.67
.852	.644	.807	.768	S.	SE.	E. SE.	2	4	2	2.3	S. 41 E.	5	3	0	.....	.....
.916	.537	.846	.766	E.	NE.	N.	2	4	2	2.3	N. 45 E.	8	2	3	.....	.....
.685	.537	.843	.688	SE.	SE.	SE.	2	2	2	2.0	S. 45 E.	1	0	0	.....	.....
.780	.551	.786	.706	NE.	NE.	NE.	2	25	12	13.0	N. 45 E.	0	3	0	.....	.....
.697	.618	.804	.706	SE.	S.	SW.	2	12	2	4.9	South.	5	7	8	.....	.61
.564	.574	.841	.660	SW.	W.	NW.	2	2	2	1.6	West.	9	3	0	.....	.27
.895	.564	.850	.770	NE.	E.	SW.	4	2	2	1.3	N. 69 E.	4	4	7	.....	.09
.747	.629	.810	.729	SW.	SW.	SW.	2	2	4	2.6	S. 45 W.	1	5	2	.....	.....
.852	.569	.764	.728	SE.	E.	S.	2	2	2	1.6	S. 45 E.	2	5	6	.....	.....
.848	.565	.749	.721	SW.	SW.	SW.	2	2	2	2.0	S. 45 W.	0	0	0	.....	.....
.799	.634	.949	.794	S.	SE.	SW.	2	12	4	5.0	S. 22 E.	1	5	5	.....	.30
.231	.539	.806	.525	W.	W. NW.	NW.	12	4	25	13.0	N. 60 W.	1	4	0	.....	.....
.731	.501	.783	.672	N.	E.	NE.	2	2	2	1.6	N. 45 E.	0	3	4	.....	.....
.769	.868	.799	.812	S.	E.	E.	2	2	2	1.7	S. 24 E.	5	7	0	.....	.....
.790	.489	.823	.701	NE.	NE.	NE.	2	4	12	6.0	N. 45 E.	7	3	0	.....	.....
.802	.492	.810	.701	S.	S.	S.	2	12	4	6.0	South.	2	1	0	.....	.....
.768	.497	.771	.679	S.	E.	E.	4	4	2	2.7	S. 58 E.	3	5	0	.....	.....
.852	.501	.771	.708	NE.	NE.	NE.	4	12	25	13.7	N. 45 E.	0	2	2	.....	.....
.804	.585	.771	.720	S.	S. SW.	SW.	2	2	4	2.3	S. 31 W.	5	0	1	.....	.41
.786	.550	.751	.696	S.	S.	S.	2	12	4	6.0	South.	0	1	3	.....	.....
.796	.554	.754	.701	SW.	SW.	W.	25	25	2	17.3	S. 46 W.	4	5	0	.....	.....
.735	.527	.786	.683	W.	NW.	N.	4	12	2	5.3	N. 50 W.	3	5	0	.....	.....
.727	.166	.613	.502	N.	E.	S.	2	2	12	3.7	S. 11 E.	3	1	0	.....	.....
.950	.543	.673	.722	SW.	SW.	W.	25	25	2	17.3	S. 46 W.	5	2	3	.....	.....
.778	.547	.788	.704	.....	.....	.....	....	....	....	0.9	S. 39 W.	3.3	3.4	2.6	.....	3.28

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
July 1	29.335	29.302	29.303	29.313	61	77	67	66	90	74	76.7	90	60	.470	.752	.568	.597
2	29.385	29.297	29.307	29.330	63	79	77	66	92	83	80.3	95	61	.536	.814	.846	.732
3	29.312	29.312	29.357	29.327	70	74	76	74	86	85	81.7	90	72	.679	.677	.775	.710
4	29.220	.....	29.195	29.208	71	....	70	77	....	75	76.0	93	74	.678	....	.666	.672
5	29.200	29.110	29.072	29.127	71	75	69	74	83	75	77.3	85	73	.718	.760	.628	.702
6	29.220	29.234	29.247	29.234	64	73	70	69	80	79	76.0	84	67	.529	.717	.612	.619
7	29.200	29.310	29.382	29.331	68	70	65	71	81	71	74.3	85	68	.644	.585	.537	.589
8	29.473	29.440	29.380	29.431	59	71	61	63	85	66	71.0	87	56	.447	.545	.479	.487
9	29.536	29.538	29.533	29.536	55	65	61	58	75	66	66.3	75	55	.393	.483	.470	.449
10	29.524	29.428	29.352	29.435	52	71	66	57	84	75	72.0	85	55	.322	.583	.519	.475
11	29.303	29.269	29.294	29.289	65	78	70	71	88	77	78.7	83	58	.537	.823	.639	.666
12	29.401	29.413	29.478	29.431	61	66	57	66	74	62	67.3	77	62	.470	.532	.399	.467
13	29.532	29.533	29.578	29.548	55	68	61	57	79	66	67.3	79	47	.407	.537	.470	.471
14	29.583	29.493	29.425	29.500	62	67	67	65	79	72	72.0	79	57	.516	.591	.595	.537
15	29.365	29.314	29.418	29.366	68	74	64	73	86	71	76.7	87	68	.618	.677	.503	.599
16	29.533	29.525	29.513	29.524	59	69	61	61	80	67	69.3	84	57	.473	.561	.457	.497
17	29.588	29.548	29.543	29.560	61	70	59	67	80	64	70.3	83	57	.457	.568	.433	.486
18	29.521	29.560	29.563	29.548	59	75	66	63	87	71	73.7	88	56	.447	.705	.572	.575
19	29.403	29.458	29.468	29.443	62	70	66	66	83	71	73.3	83	59	.502	.558	.572	.544
20	29.594	29.492	29.471	29.521	56	70	65	59	81	71	70.3	87	55	.409	.585	.537	.510
21	29.453	29.324	29.315	29.364	65	79	71	70	93	78	80.3	93	59	.550	.800	.664	.671
22	29.323	29.267	29.230	29.273	62	78	72	66	93	77	78.7	96	65	.502	.755	.718	.658
23	29.345	29.331	29.337	29.338	66	80	75	70	94	81	81.7	97	67	.586	.833	.787	.735
24	29.362	29.329	29.294	29.328	68	80	87	72	97	79	82.7	98	70	.631	.792	.....	.712
25	29.213	29.184	29.230	29.209	71	71	72	76	85	77	79.3	86	73	.691	.570	.719	.660
26	29.198	29.237	29.250	29.228	70	71	72	72	83	76	77.0	89	70	.706	.597	.731	.678
27	29.263	29.177	29.172	29.204	65	82	77	69	92	82	81.0	94	62	.564	.956	.860	.793
28	29.167	29.047	29.198	29.137	76	71	69	79	84	74	79.0	90	74	.856	.583	.641	.693
29	29.393	29.478	29.505	29.459	61	70	60	66	82	65	71.0	83	60	.470	.572	.451	.498
30	29.644	29.545	29.513	29.567	53	70	62	55	83	69	69.0	83	51	.276	.558	.462	.465
31	29.376	29.236	29.293	29.335	65	68	62	59	74	65	66.0	74	59	.....	.604	.516	.560
Means...	29.389	29.361	29.362	29.369	63.4	70.4	67.6	67.0	81.7	73.3	77.9	98	47	.539	.654	.594	.601
August 1	29.208	29.153	29.155	29.172	61	79	68	66	83	71	73.3	84	61	.470	.936	.644	.683
2	29.198	29.240	29.285	29.241	61	71	72	66	79	76	73.7	80	58	.470	.651	.731	.617
3	29.456	29.480	29.503	29.480	61	75	70	67	87	73	75.7	87	56	.457	.705	.693	.618
4	29.556	29.487	29.557	29.533	59	81	72	61	93	77	77.0	93	56	.473	.894	.718	.695
5	29.503	29.573	29.487	29.521	62	80	78	65	95	81	80.3	96	62	.516	.820	.918	.751
6	29.515	29.504	29.493	29.504	68	80	73	71	90	77	79.3	90	67	.644	.897	.757	.766
7	29.523	29.524	29.475	29.507	61	82	73	66	94	76	78.7	95	65	.470	.929	.771	.723
8	29.473	29.397	29.395	29.422	70	81	73	72	93	79	81.3	93	63	.706	.894	.730	.777
9	29.405	29.357	29.413	29.392	65	82	72	70	97	79	82.0	97	68	.550	.889	.690	.709
10	29.531	29.552	29.678	29.587	65	76	64	69	85	78	77.3	87	68	.564	.775	.409	.583
11	29.598	29.591	29.558	29.582	54	75	61	68	86	64	72.7	87	52	.232	.719	.497	.483
12	29.469	29.243	29.144	29.285	68	82	73	60	96	81	79.0	96	55	.....	.902	.703	.803
13	29.125	29.290	29.192	29.202	70	75	69	73	80	71	74.7	82	71	.693	.800	.682	.725
14	29.351	29.365	29.435	29.384	61	77	67	63	85	70	72.7	87	61	.510	.819	.662	.650
15	29.481	29.462	29.448	29.430	58	77	65	61	87	70	72.7	89	59	.443	.792	.550	.595
16	29.453	29.378	29.338	29.390	57	75	67	59	90	72	73.7	91	58	.439	.665	.585	.566
17	29.261	29.277	29.179	29.239	57	81	76	61	94	85	80.0	98	57	.412	.880	.775	.689
18	29.232	29.209	29.132	29.191	72	81	68	76	96	75	82.3	96	70	.731	.853	.591	.725
19	29.268	29.270	29.380	29.306	60	75	65	65	90	69	74.7	90	61	.451	.665	.564	.560
20	29.456	29.448	29.433	29.446	57	74	64	59	86	68	71.0	86	59	.439	.677	.529	.548
21	29.436	29.365	29.353	29.385	65	75	67	68	85	73	75.3	89	56	.577	.733	.581	.630
22	29.338	29.300	29.298	29.312	55	75	68	56	90	76	74.0	92	54	.420	.665	.577	.554
23	29.210	29.182	29.195	29.196	58	81	71	65	95	77	79.0	95	63	.389	.867	.678	.645
24	29.308	29.350	29.398	29.352	64	75	63	67	85	68	73.3	87	63	.556	.733	.549	.599
25	29.554	29.493	29.516	29.521	48	72	62	51	84	67	67.3	85	50	.296	.623	.469	.463
26	29.556	29.408	29.403	29.456	53	75	68	55	86	73	71.3	88	54	.376	.719	.618	.571
27	29.366	.....	29.117	29.242	57	....	76	58	....	82	70.0	93	57	.452	....	.816	.634
28	29.168	29.157	29.187	29.171	68	75	64	73	85	66	74.7	86	66	.618	.733	.569	.640
29	29.284	29.308	29.416	29.336	53	65	54	55	75	68	66.0	87	50	.376	.483	.232	.364
30	29.592	29.571	29.541	29.568	42	64	56	43	76	61	60.0	78	42	.251	.436	.383	.358
31	29.351	29.276	29.163	29.263	51	61	64	56	67	67	63.3	68	52	.308	.457	.556	.440
Means...	29.394	29.374	29.363	29.375	60.0	73.4	67.8	63.4	87.1	73.2	74.4	98	42	.476	.754	.619	.618

the northern and northwestern lakes at Monroe City, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.735	.534	.677	.649	NE ...	NE ...	E	4	2	2	2.7	N. 58 E.	2	3	0	.....	.....
.838	.543	.750	.710	S	SE....	SE....	2	4	4	3.0	S. 36 E.	1	1	5	.....	.....
.810	.545	.644	.666	SW ..	SW ..	S	4	25	4	10.7	S. 40 W.	0	4	4	.....	.02
.731	.....	.768	.750	SE.....	.....	SW ..	4	.....	2	1.7	S. 16 E.	2	.....	2	.....	.....
.856	.673	.724	.781	W	NW ..	NW ..	2	4	2	2.7	N. 58 W.	8	7	8	.....	.93
.747	.701	.618	.689	SW ..	SW ..	SW ..	4	2	2	2.6	S. 45 W.	3	2	1	.....	.99
.850	.544	.708	.701	SW ..	SW ..	NW...	4	2	2	2.0	S. 62 W.	4	0	0	.....	.....
.776	.468	.735	.660	NW...	NW...	NW...	2	2	2	2.0	N. 45 W.	1	1	9	.....	.....
.816	.558	.735	.703	N	N	N	12	2	4	6 0	North ..	1	2	0	.....	.39
.692	.501	.599	.597	NW...	W	W	4	4	12	6.3	N. 82 W.	5	3	2	.....	.....
.708	.622	.689	.673	SW ..	SW ..	W	35	12	4	16.7	S. 48 W.	3	4	2	.....	.....
.735	.634	.718	.696	NE ...	NE ...	NE ...	4	25	2	10.3	N. 45 E.	7	3	2	.....	.03
.874	.542	.735	.717	NE ...	NE ...	NE ...	2	12	25	13.0	N. 45 E.	0	1	1	.....	.....
.836	.506	.758	.700	E	E	E	2	25	12	13.0	East ...	5	4	6	.....	.....
.761	.545	.663	.656	SW ..	SW ..	W	12	12	2	8.7	S. 47 W.	5	8	0	.....	.....
.882	.548	.690	.707	N	N	N	2	4	2	2.7	North ..	0	2	1	.....	.....
.690	.585	.727	.667	NE ...	NE ...	N	4	4	2	3.0	N. 36 E.	2	2	3	.....	.....
.776	.550	.754	.693	N	N. NE.	E	2	12	2	5.0	N. 26 E.	5	3	2	.....	.....
.786	.495	.754	.678	E	E	E	2	12	2	5.3	East ...	7	5	1	.....	.....
.819	.554	.708	.694	NE ...	SE....	SE....	2	2	2	1.7	S. 74 E.	1	3	0	.....	.....
.751	.518	.693	.654	S	S	S	2	2	2	2.0	South ..	0	2	3	.....	.....
.786	.488	.774	.683	SW ..	SW ..	SW ..	4	2	4	3.3	S. 45 W.	1	5	5	.....	.....
.799	.522	.744	.688	S	S	S	2	12	4	6.0	South ..	1	2	3	.....	.....
.804	.453	.....	.629	SW ..	SW ..	SW ..	2	4	2	2.6	S. 45 W.	7	5	5	.....	.....
.771	.474	.774	.673	W	W	W	4	4	4	4.0	West ..	4	9	10	.....	.....
.900	.529	.815	.748	NW...	NE ...	SE ..	2	12	2	4.0	N. 45 E.	10	3	0	.....	.07
.796	.637	.787	.740	SE....	S	SW ..	2	2	2	1.6	South ..	4	2	1	.....	.....
.865	.501	.764	.710	SW ..	SW ..	W	12	4	2	6.0	S. 50 W.	7	2	0	.....	.....
.735	.524	.731	.663	NW ..	NW ..	N	25	4	2	10.0	N. 42 W.	5	4	2	.....	.20
.869	.495	.653	.672	N	NE ...	NE ...	2	4	2	2.7	N. 32 E.	1	0	3	.....	.....
.....	.720	.836	.778	NE ...	S	N	4	4	2	1.0	N. 75 E	10	10	2	.....	.....
.793	.550	.724	.691	.....	.....	.....	....	....	....	0.3	N. 89 W.	3.6	3.3	2.7	.....	2.63
.735	.830	.850	.805	SW ..	SW ..	W	2	2	2	1.7	S. 56 W.	9	9	0	.....	.16
.735	.657	.815	.736	NW ..	NW ..	N	4	4	2	3.0	N. 37 W.	3	5	3	.....	.13
.690	.550	.854	.698	E	E	E	2	2	2	2.0	East ..	2	2	1	.....	.....
.882	.578	.774	.745	S	S	S	4	2	2	2.7	South ..	3	5	4	.....	.....
.836	.498	.868	.734	W	SE....	S	2	4	2	1.7	S. 10 E.	1	4	3	.....	.....
.850	.630	.817	.766	W	W	NW ..	2	4	2	2.7	N. 80 W.	6	2	1	.....	.....
.735	.582	.860	.726	S	S	S	2	2	2	2.0	South ..	4	2	1	.....	.15
.900	.578	.738	.739	SE....	NE ...	E	4	4	4	3.2	East ...	1	2	3	.....	.....
.751	.507	.697	.652	SW ..	SW ..	NW ..	2	2	4	1.9	West...	4	2	8	.....	.....
.796	.644	.427	.622	NW ..	NW ..	NW ..	4	12	2	6.0	N. 45 W.	6	0	0	.....	.30
.340	.579	.833	.584	N	NE ...	NE ...	2	12	12	8.7	N. 41 E	0	0	0	.....	.....
.....	.532	.665	.599	E	W	W	2	4	4	2.0	West...	1	3	8	.....	.....
.854	.782	.899	.845	NW ..	N	NW ..	12	4	4	6.3	N. 37 W.	9	5	0	.....	.53
.886	.681	.848	.805	W	W	W	2	2	2	2.0	West...	5	2	0	.....	.....
.825	.618	.751	.731	S	E	N	2	2	2	0.7	East ...	0	2	0	.....	.....
.878	.472	.758	.703	N	NW ..	E	2	2	4	1.3	N. 38 E.	5	0	0	.....	.....
.769	.552	.644	.655	SE....	SE....	S	4	25	2	10.0	S. 42 E.	1	7	2	.....	.....
.815	.503	.681	.666	W	W. SW	SW ..	4	35	4	14.3	S. 67 W.	4	3	2	.....	.....
.731	.472	.796	.666	W	W	NW ..	2	2	2	2.0	N. 77 W.	3	5	4	.....	.....
.878	.545	.747	.723	N	N	N	2	4	2	2.7	North ..	2	3	0	.....	.....
.843	.609	.716	.723	NE ...	SE....	SW ..	2	12	2	4.0	S. 45 E.	1	2	2	.....	.....
.935	.472	.644	.684	SW ..	NE ...	N	2	12	2	4.0	N. 36 E.	0	0	0	.....	.....
.631	.527	.731	.630	W	W	W	2	2	2	2.0	West...	7	3	0	.....	.....
.841	.609	.743	.764	W	NW ..	NW ..	2	4	4	3.0	N. 52 W.	0	3	0	.....	.47
.790	.535	.740	.688	N	N	N	2	4	2	2.7	North ..	0	0	0	.....	.....
.869	.579	.761	.736	NW ..	NE ...	NE ...	2	4	12	5.3	N. 38 E.	3	4	2	.....	.....
.937	.....	.747	.842	E	.....	NE ...	2	....	4	1.7	N. 56 E.	1	....	7	.....	.....
.761	.609	.891	.754	NW ..	NW ..	N	4	25	2	10.0	N. 42 W.	4	5	2	.....	.32
.869	.558	.340	.589	N	NW ..	NE ...	2	25	2	9.0	N. 38 W.	3	7	3	.....	.....
.916	.486	.713	.705	E	SE....	SE....	4	12	12	9.0	S. 51 E.	0	0	1	.....	.....
.687	.690	.841	.739	S	S	S	25	4	12	13.7	South ..	9	10	10	.....	.....
.798	.582	.748	.711	.....	.....	.....	....	....	....	0.6	N. 55 W.	3.1	3.1	2.2	.....	2.06

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Sept. 1	29.304	29.356	29.386	29.349	58	61	51	61	68	55	61.3	69	55	.443	.443	.321	.402
2	29.442	29.399	29.366	29.402	42	68	55	43	75	58	58.7	75	40	.254	.591	.393	.413
3	29.286	29.296	29.351	29.311	53	68	58	55	75	61	63.7	75	55	.376	.591	.443	.470
4	29.434	29.403	29.386	29.408	45	68	61	47	76	64	62.3	76	45	.273	.577	.497	.449
5	29.326	29.292	29.236	29.285	55	80	72	60	90	75	75.0	91	55	.367	.897	.644	.636
6	29.187	29.393	29.496	29.359	65	62	53	68	69	56	64.3	69	56	.577	.462	.363	.467
7	29.677	29.656	29.656	29.663	55	72	55	56	76	58	63.3	76	46	.420	.731	.393	.515
8	29.677	29.656	29.636	29.663	55	70	64	58	78	68	68.0	78	47	.393	.625	.543	.520
9	29.617	29.510	29.373	29.500	59	73	62	62	84	66	70.7	86	61	.460	.663	.502	.542
10	29.534	29.546	29.546	29.542	52	63	52	56	73	57	62.0	76	53	.335	.448	.322	.368
11	29.582	29.484	29.378	29.481	42	73	55	46	81	59	62.0	81	38	.215	.703	.380	.433
12	29.352	29.258	29.245	29.285	50	75	62	52	84	67	67.7	87	47	.334	.746	.489	.523
13	29.178	29.205	29.416	29.266	62	71	56	65	74	59	66.0	77	59	.516	.718	.409	.548
14	29.518	29.541	29.594	29.568	52	61	54	56	69	57	60.7	69	42	.335	.430	.378	.381
15	29.494	29.441	29.445	29.460	60	71	65	63	78	70	70.3	78	47	.478	.664	.550	.564
16	29.465	29.444	29.452	29.454	70	83	81	73	96	86	84.0	96	67	.693	.951	.989	.878
17	29.598	29.549	29.550	29.566	65	82	73	69	97	79	81.7	98	68	.564	.888	.730	.727
18	29.595	29.557	29.577	29.576	67	80	73	70	91	79	80.0	91	69	.622	.874	.739	.745
19	29.598	29.505	29.435	29.513	64	72	71	67	85	76	76.0	87	66	.556	.649	.691	.619
20	29.398	29.505	29.570	29.491	69	61	62	73	72	66	70.3	83	66	.655	.390	.502	.516
21	29.663	29.607	29.605	29.625	53	71	61	54	79	63	65.3	81	54	.389	.651	.510	.517
22	29.542	29.515	29.523	29.527	51	71	62	53	81	68	67.3	81	47	.348	.624	.476	.483
23	29.759	29.758	29.768	29.762	53	70	56	54	77	57	62.7	78	53	.389	.639	.436	.488
24	29.710	29.758	29.435	29.574	53	73	65	54	84	68	68.7	87	42	.389	.663	.577	.543
25	29.471	29.565	29.601	29.546	59	66	55	62	75	57	64.7	77	56	.460	.519	.407	.462
26	29.602	29.592	29.533	29.576	44	59	47	45	63	49	52.3	65	44	.275	.447	.297	.340
27	29.505	29.423	29.380	29.436	35	63	58	36	73	61	56.7	75	35	.191	.442	.443	.359
28	29.342	29.288	29.236	29.289	47	73	61	49	87	64	66.7	88	39	.297	.623	.497	.472
29	29.309	29.424	29.607	29.447	58	61	45	61	67	46	58.0	67	45	.443	.457	.286	.395
30	29.635	29.640	29.539	29.605	38	61	41	39	67	43	49.7	68	37	.216	.457	.231	.301
Means....	29.493	29.480	29.478	29.484	54.2	69.4	59.5	56.9	78.1	63.1	66.0	98	35	.408	.617	.481	.502
Oct. 1	29.466	29.291	29.236	29.331	30	65	45	32	78	60	56.7	78	30	.144	.443	.234	.274
2	29.060	29.072	29.269	29.134	51	63	56	56	72	59	62.3	73	56	.308	.455	.409	.391
3	29.380	29.377	29.380	29.379	42	55	48	46	59	49	51.3	59	42	.215	.380	.322	.305
4	29.372	29.304	29.207	29.294	52	59	53	56	67	56	59.7	67	39	.335	.393	.363	.364
5	29.220	29.510	29.560	29.430	46	55	46	47	59	46	50.7	59	47	.297	.380	.311	.329
6	29.721	29.770	29.787	29.759	39	58	47	43	67	49	53.0	67	41	.186	.376	.297	.286
7	29.898	29.841	29.767	29.835	33	52	45	35	57	48	46.7	57	32	.162	.322	.360	.282
8	29.715	29.587	29.447	29.583	35	57	53	36	67	56	53.0	67	35	.191	.333	.363	.296
9	29.150	29.038	29.021	29.070	52	52	52	55	62	54	57.0	63	52	.349	.256	.302	.302
10	28.866	28.853	28.898	28.872	52	50	47	56	56	49	53.7	56	49	.335	.282	.297	.305
11	28.996	29.081	29.172	29.083	47	51	49	49	55	51	51.7	56	47	.297	.321	.321	.313
12	29.246	29.257	29.385	29.296	48	50	50	49	54	50	51.0	55	48	.322	.308	.361	.330
13	29.227	29.468	29.501	29.399	51	53	52	54	60	54	56.0	62	46	.335	.310	.362	.336
14	29.503	29.359	29.379	29.414	37	51	51	40	68	57	55.0	70	37	.181	.150	.295	.209
15	29.405	29.381	29.459	29.415	45	65	51	49	75	55	59.7	75	46	.247	.483	.331	.354
16	29.547	29.502	29.411	29.487	40	70	63	41	82	70	64.3	84	39	.235	.572	.488	.430
17	29.431	29.330	29.313	29.358	58	68	62	63	82	71	72.0	83	60	.416	.497	.426	.450
18	29.306	29.292	29.343	29.314	53	67	62	57	84	72	71.0	85	57	.350	.434	.631	.472
19	29.361	29.373	29.428	29.387	57	69	62	61	88	70	73.0	89	60	.412	.480	.448	.447
20	29.546	29.448	29.441	29.478	49	71	59	51	84	63	66.0	84	45	.321	.583	.447	.450
21	29.414	29.345	29.411	29.390	47	66	62	50	80	65	65.0	81	49	.283	.432	.516	.617
22	29.632	29.622	29.722	29.659	45	49	41	47	57	43	49.0	64	43	.273	.342	.231	.282
23	29.872	29.860	29.834	29.855	29	51	35	30	57	37	41.3	57	29	.149	.295	.178	.207
24	29.888	29.762	29.767	29.806	26	51	41	27	60	44	43.7	60	24	.129	.255	.218	.201
25	29.791	29.702	29.674	29.722	30	47	50	31	56	52	46.3	60	27	.155	.304	.334	.264
26	29.667	29.664	29.674	29.668	41	57	49	44	58	51	51.0	59	43	.218	.438	.331	.329
27	29.690	29.650	29.611	29.650	39	56	47	41	62	50	51.0	62	36	.212	.369	.253	.278
28	29.567	29.482	29.420	29.490	41	48	51	46	56	53	51.7	59	40	.192	.230	.348	.257
29	29.412	29.339	29.351	29.367	49	60	54	51	67	56	58.0	65	50	.321	.425	.391	.379
30	29.297	29.253	29.286	29.279	47	35	33	49	39	34	40.7	56	34	.297	.158	.175	.210
31	29.438	29.480	29.527	29.482	40	47	42	41	53	44	46.0	53	34	.235	.244	.241	.240
Means....	29.454	29.429	29.441	29.441	45.0	58.3	52.1	47.8	67.4	55.6	56.9	89	24	.270	.369	.352	.330

the northern and northwestern lakes at Monroe City, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.925	.647	.743	.738	N.....	N.....	N.....	12	2	2	5.3	North..	10	5	2	.....	.45
.916	.681	.816	.804	NW..	NE...	SE....	2	4	2	1.3	N. 45 E.	0	4	3	.....	.....
.869	.681	.825	.792	W....	W....	W....	4	4	4	4.0	West...	4	10	3	.....	.....
.847	.644	.833	.775	NW..	NE...	NE...	2	12	4	5.3	N. 38 E.	0	2	5	.....	.22
.708	.630	.858	.732	E.....	E.....	E.....	2	2	2	2.0	East...	0	2	2	.....	.....
.843	.653	.809	.768	W....	NW..	N.....	2	4	2	2.3	N. 45 W.	4	2	0	.....	.....
.935	.815	.816	.855	NE...	NE...	NE...	2	12	4	6.0	N. 45 E.	5	1	0	.....	.....
.816	.653	.793	.754	E.....	NE...	NE...	2	12	4	6.0	N. 50 E.	0	0	10	.....	.....
.828	.569	.786	.728	SE....	SW..	W....	2	4	12	4.7	S. 73 W.	2	8	10	.....	.....
.747	.545	.692	.661	NW..	NW..	N.....	4	2	2	2.7	N. 32 W.	10	1	0	.....	.07
.691	.665	.761	.706	SE....	S.....	W....	12	2	4	3.7	S. 25 E.	0	0	0	.....	.....
.861	.640	.740	.747	NW..	NW..	NW..	25	12	4	13.7	N. 45 W.	5	4	4	.....	.....
.836	.856	.819	.837	NW..	W....	NW..	4	4	4	3.7	N. 60 W.	6	10	7	.....	.....
.747	.607	.812	.722	NE...	NE...	NE...	25	25	4	18.0	N. 45 E.	0	2	2	.....	.14
.831	.693	.751	.758	E.....	E.....	S.....	2	25	2	9.3	S. 86 E.	0	0	10	.....	.....
.854	.561	.797	.737	SW..	SW..	SW..	4	4	2	3.3	S. 45 W.	6	3	2	.....	.06
.796	.507	.738	.680	S.....	S.....	SW...	2	2	4	9.3	S. 4 W.	5	0	0	.....	.....
.848	.601	.738	.729	SW..	SW..	W....	4	12	2	6.0	S. 50 W.	4	8	0	.....	.....
.841	.507	.771	.706	N.....	E.....	SE....	2	4	2	1.7	N. 83 E.	9	1	0	.....	.04
.807	.497	.786	.697	SW..	SW..	W....	12	35	2	16.3	S. 47 W.	0	3	2	.....	.....
.933	.657	.886	.825	N.....	E.....	SE....	2	4	2	1.7	N. 83 E.	3	3	0	.....	.....
.864	.590	.695	.716	W....	W....	W....	12	12	4	9.3	West..	2	2	2	.....	.....
.933	.689	.936	.853	N.....	NE...	NE...	2	12	12	8.7	N. 43 E.	0	0	0	.....	.....
.933	.569	.843	.782	E.....	SE....	S.....	2	4	2	2.3	S. 45 E.	0	3	1	.....	.....
.828	.599	.874	.767	SW..	NW..	N.NE.	2	4	12	4.0	N. 2 E..	7	6	2	.....	.....
.920	.776	.853	.850	NE...	NE...	NE...	2	4	4	3.3	N. 45 E.	3	7	6	.....	.....
.900	.545	.825	.757	NE..	E.....	SE....	2	2	2	1.6	East...	0	0	0	.....	.....
.853	.486	.833	.724	S.....	S.....	S.....	4	4	2	3.3	South..	0	1	1	.....	.....
.825	.690	.921	.812	SW..	NW..	NW..	4	45	12	19.0	N. 49 W.	4	5	2	.....	.....
.907	.690	.833	.810	NE...	SE....	SE....	2	2	2	1.7	S. 74 E.	4	0	2	.....	.....
.845	.631	.806	.761	.....	.....	.....	....	....	....	1.5	N. 17 W.	3.1	3.1	2.6	.....	.98
.794	.463	.646	.634	SW..	SW..	W....	2	12	4	5.7	S. 55 W.	2	0	5	.....	.....
.687	.582	.819	.696	NW..	W....	NW..	4	12	12	8.7	N. 64 W.	10	5	10	.....	.....
.691	.761	.926	.793	W....	N.....	N.....	4	4	4	3.0	N. 27 W.	6	4	0	.....	.06
.747	.595	.809	.717	N.....	NE...	NE...	2	12	12	8.7	N. 41 E.	7	4	10	.....	.....
.923	.761	1.000	.895	N.....	N.....	N.....	2	2	2	2.0	North..	10	3	1	.....	.03
.669	.588	.853	.703	NE...	E.....	SE....	2	4	2	2.3	East...	10	0	0	.....	.....
.797	.692	.777	.755	SE....	NE...	NE...	2	4	4	3.0	N. 62 E.	1	1	4	.....	.....
.900	.503	.809	.737	N.....	E.....	S.....	2	4	2	1.3	East...	0	3	4	.....	.....
.805	.461	.867	.711	SW..	SW..	SW..	4	12	25	13.7	S. 45 W.	10	7	6	.....	.28
.747	.627	.853	.742	S.....	SW..	SW..	2	25	12	13.0	S. 43 W.	7	10	9	.....	.39
.853	.743	.859	.818	NW..	NW..	NW..	4	12	4	6.7	N. 45 W.	8	7	10	.....	.07
.926	.738	1.000	.888	W....	W....	W....	2	2	4	2.7	West...	10	6	10	.....	.....
.802	.599	.867	.756	NW..	NW..	N.....	4	12	2	6.0	N. 40 W.	3	3	2	.....	.19
.732	.219	.634	.528	W....	S.SW.	SW...	2	4	2	2.3	S. 43 W.	6	2	0	.....	.....
.710	.558	.743	.670	SW..	SW...	SW...	4	2	4	3.3	S. 45 W.	7	3	0	.....	.....
.912	.524	.658	.698	NE...	E.....	SE....	2	4	4	3.0	S. 81 E.	0	4	2	.....	.....
.723	.455	.576	.585	S.....	SW...	SW...	12	35	12	19.0	S. 37 W.	0	1	0	.....	.....
.752	.372	.804	.643	S.....	S.....	S.....	2	2	2	2.0	South..	0	0	0	.....	.....
.769	.387	.613	.590	SE....	SE....	SE....	2	12	2	5.3	S. 45 E.	0	1	0	.....	.....
.859	.501	.776	.712	E.....	E.....	E.....	2	2	2	2.0	East...	0	0	0	.....	.....
.786	.441	.836	.688	SE....	SW...	W....	2	2	4	1.7	S. 56 W.	4	7	10	.....	.....
.847	.521	.833	.734	NW..	NW..	N.....	2	4	2	2.7	N. 31 W.	4	3	3	.....	.....
.890	.634	.807	.777	NE...	NE...	NE...	2	25	35	20.7	N. 45 E.	0	1	2	.....	.....
.880	.493	.756	.710	E.....	E.....	E.....	2	4	4	3.3	East...	0	3	2	.....	.....
.893	.455	.861	.736	E.....	NE...	NE...	2	12	2	5.0	N. 49 E.	3	5	2	.....	.....
.756	.878	.859	.831	SE....	S.....	E.....	2	2	2	1.3	S. 69 E.	1	1	10	.....	.....
.824	.665	.786	.758	NE...	NE...	N.....	4	12	2	6.0	N. 40 E.	2	0	0	.....	.....
.617	.512	.864	.664	NE...	NE...	NE...	4	4	12	6.7	N. 45 E.	7	10	10	.....	.....
.859	.642	.872	.791	NW..	NW..	NW..	2	2	2	2.0	N. 45 W.	10	5	10	.....	.....
.853	.636	.895	.795	W....	W....	W....	2	4	4	3.3	West..	10	10	10	.....	.06
.912	.606	.836	.785	W....	W....	W....	2	4	2	2.7	West...	10	7	0	.....	.34
.830	.587	.836	.751	.....	.....	.....	....	....	....	0.6	N. 68 W.	4.6	3.7	4.2	.....	1.42

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Nov. 1	29.366	29.101	29.065	29.177	39	59	55	41	67	57	55.0	67	37	.212	.393	.407	.337
2	29.671	29.128	29.212	29.137	55	53	47	57	62	52	57.0	62	50	.407	.284	.257	.316
3	28.923	28.670	28.752	28.782	50	57	51	52	65	54	57.0	65	50	.334	.359	.335	.342
4	29.311	29.513	29.686	29.503	39	37	32	40	42	33	38.3	54	33	.225	.153	.162	.183
5	29.747	29.676	29.688	29.704	28	45	38	29	50	39	39.3	50	27	.142	.234	.216	.197
6	29.706	29.608	29.483	29.599	31	47	37	32	54	39	41.7	54	29	.162	.231	.194	.196
7	29.313	29.182	29.123	29.206	40	53	48	42	64	51	55.7	67	35	.221	.257	.296	.258
8	29.111	29.028	28.958	29.032	42	60	57	47	67	63	59.0	70	46	.262	.425	.366	.338
9	29.151	29.212	29.312	29.225	42	60	40	46	66	44	52.0	67	44	.215	.438	.195	.283
10	29.348	29.315	29.360	29.341	38	48	41	42	60	45	49.0	60	40	.177	.177	.205	.186
11	29.411	29.428	29.521	29.453	42	35	33	45	44	35	41.3	47	33	.228	.087	.162	.159
12	29.589	29.596	29.469	29.551	28	33	32	29	35	34	32.7	39	29	.142	.162	.155	.153
13	29.374	29.341	29.276	29.330	29	45	33	30	49	35	38.0	50	30	.149	.247	.162	.186
14	29.086	29.183	29.389	29.219	39	44	37	42	50	42	44.7	52	35	.199	.209	.155	.189
15	29.652	29.574	29.246	29.491	25	38	38	26	50	41	39.0	50	24	.123	.072	.190	.128
16	29.346	29.506	29.534	29.462	34	37	32	39	49	35	41.0	49	33	.131	.064	.142	.112
17	29.331	29.283	29.286	29.300	37	40	37	39	45	39	41.0	46	37	.194	.192	.194	.193
18	29.434	29.476	29.526	29.479	21	30	24	22	34	25	27.0	41	22	.101	.121	.117	.113
19	29.673	29.635	29.516	29.608	12.5	38	30	13	45	32	30.0	45	12	.076	.138	.144	.119
20	29.434	29.363	29.444	29.414	27	49	39	28	57	42	42.3	57	27	.136	.242	.199	.192
21	29.467	29.431	29.418	29.439	25	46	36	26	52	38	38.7	52	23	.123	.232	.186	.180
22	29.368	29.313	29.313	29.331	40	47	47	43	56	49	49.3	57	36	.208	.204	.297	.236
23	29.413	29.400	29.405	29.406	36	58	46	49	64	48	53.7	64	35	.042	.403	.284	.243
24	29.305	29.232	29.252	29.263	46	58	57	48	64	60	57.3	64	46	.284	.403	.426	.371
25	29.157	29.058	29.158	29.124	52	42	45	54	59	47	53.3	59	47	.362	.175	.273	.270
26	29.421	29.563	29.583	29.522	38	40	39	41	46	40	42.3	49	39	.190	.169	.216	.192
27	29.526	29.424	29.467	29.439	37	41	38	40	46	40	42.0	47	38	.181	.192	.203	.192
28	29.433	29.360	29.316	29.370	38	39	39	39	43	40	40.7	44	37	.216	.186	.225	.209
29	28.964	28.767	29.085	28.939	40	33	24	42	35	26	34.3	42	24	.221	.163	.106	.163
30	29.393	29.491	29.606	29.497	12.5	16	16	13	18	17	16.0	26	11.5	.076	.067	.078	.074
Means...	29.364	29.328	29.345	29.346	35.4	44.3	38.9	37.9	51.3	41.4	43.5	70	12	.189	.222	.219	.210
Dec. 1	29.579	29.456	29.463	29.499	35	23	26	15	27	27	23.0	27	7	.063	.078	.129	.090
2	29.395	29.462	29.534	29.464	27	32	28	28	39	29	32.0	39	24	.136	.090	.142	.123
3	29.553	29.334	29.290	29.392	22	30	31	24	35	33	30.7	35	20	.095	.109	.151	.118
4	29.295	29.247	29.182	29.241	14	24	21	15	27	22	21.3	33	14	.071	.095	.101	.089
5	29.196	29.270	29.282	29.249	22.5	27	28.5	24	31	30	28.3	31	13	.104	.101	.139	.115
6	28.943	28.718	29.183	28.948	35	43	27	37	50	30.5	39.2	51	28	.178	.186	.105	.157
7	29.408	29.443	29.511	29.454	23	30	16	24.5	32	17	24.5	32	16	.106	.144	.078	.109
8	29.669	29.625	29.605	29.633	19	24	23	21	27	24.5	24.2	27	15	.080	.085	.106	.094
9	29.646	29.512	29.288	29.482	19	31	33	20	35	35	30.0	35	16	.092	.128	.162	.127
10	29.267	29.243	29.250	29.253	32.5	35	27	34	39	29	34.0	39	29	.165	.152	.126	.147
11	29.284	29.298	29.292	29.291	28	26	24	29	29	25	27.7	29	23	.142	.106	.117	.122
12	29.236	29.231	29.411	29.293	10.5	11	8.5	11	12	9	10.7	25	-2	.064	.061	.058	.061
13	29.541	29.531	29.443	29.505	1.5	15	15	2	17	17	12.0	21	0	.041	.063	.063	.056
14	29.399	29.343	29.320	29.354	11	23	20.5	12	25	22	19.7	25	11	.061	.100	.094	.085
15	29.345	29.325	29.322	29.364	15	26	16	16	29	17	20.7	30	14	.074	.106	.078	.086
16	29.318	29.285	29.155	29.226	18	28	24	19	30	26	25.0	34	15	.087	.130	.108	.108
17	28.991	29.080	29.270	29.114	25	32	32	27	34	34	31.7	34	23	.112	.155	.153	.140
18	29.447	29.537	29.762	29.582	29	31	28	30	35	31	32.0	35	29	.149	.128	.119	.132
19	29.839	29.743	29.578	29.720	0	29	24	1	31	25	19.0	31	-1	.032	.137	.117	.095
20	29.328	29.462	29.620	29.470	28	34	32	30	37	34	33.7	35	21	.130	.157	.155	.147
21	29.635	29.443	29.137	29.405	25	30	34	27	33	36	32.0	36	18	.112	.139	.170	.140
22	28.955	29.077	29.196	29.076	41	30	30	44	33	31.5	36.2	44	31	.218	.139	.150	.169
23	29.613	29.628	29.675	29.639	27	28	26	28	33	27	29.3	33	25	.136	.096	.128	.120
24	29.420	29.371	29.362	29.384	29	40	32	31	41	34	35.3	43	24	.137	.235	.155	.176
25	29.194	28.922	28.979	29.032	37	44	46	39	49	49	45.7	55	33	.194	.223	.271	.229
26	29.436	29.433	29.227	29.365	30	36	35	32.5	40	38	36.8	41	30	.138	.160	.165	.154
27	28.876	28.926	29.262	29.021	53	53	36	57	60	39.5	52.2	61	35	.350	.310	.186	.282
28	29.486	29.464	29.514	29.488	30	31	28	33	36	30	33.0	38	28	.132	.116	.130	.126
29	29.730	29.728	29.858	29.772	23	27	22	25	30	23	26.0	30	21	.100	.113	.107	.107
30	29.915	29.958	29.961	29.941	11	25	15	12	27	16	18.3	28	9	.061	.112	.074	.082
31	29.716	29.435	29.278	29.476	19	29	26	20	31	27	26.0	31	11	.092	.137	.128	.119
Means...	29.408	29.372	29.394	29.392	23.2	29.9	26.3	24.8	33.3	28.0	28.7	55	-2	.118	.132	.127	.126

the northern and northwestern lakes at Monroe City, Michigan.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.824	.595	874	.764	NW...	SW...	SW...	4	35	12	15.7	S. 50 W	1	4	3	.....	.....
.874	.511	.660	.682	SW...	W.....	NW...	4	4	4	3.2	West..	1	1	2	.....	.....
.861	.582	.802	.748	NW...	SW...	SW...	2	25	35	2.0	S. 46 W	6	5	4	.....	.....
.910	.577	.893	.793	N.....	W.....	NW...	2	12	2	4.7	N. 76 W	5	7	6	.....	.22
.887	.646	.907	.813	SW...	SW...	W.....	4	25	2	10.0	S. 48 W	5	2	3	.....	.....
.896	.552	.816	.755	N.....	NE....	NE...	2	4	4	3.0	N. 36 E	4	5	4	.....	.....
.829	.432	.790	.684	S.....	S.....	SE....	2	4	4	3.0	S. 18 E	5	0	5	.....	.....
.624	.642	.670	.645	S.....	SE....	S. SW.	4	4	4	3.7	S. 7 E	3	7	10	.....	.....
.691	.685	.677	.684	SW...	SW...	SW...	12	4	4	6.7	S. 45 W	7	3	5	.....	.31
.661	.342	.684	.562	SW...	SW...	SW...	2	35	12	16.3	S. 45 W	2	0	0	.....	.....
.762	.299	.797	.619	W.....	NW...	NW...	4	12	4	6.3	N. 53 W	1	7	10	.....	.....
.887	.797	.792	.825	NW...	NW...	NW...	4	2	12	6.0	N. 45 W	8	5	4	.....	.....
.890	.710	.797	.799	NW...	NW...	NW...	2	25	25	17.3	N. 45 W	0	0	0	.....	.....
.744	.581	.577	.634	N. NW	N. NW	W.....	12	25	4	12.3	N. 57 W	0	2	5	.....	.....
.876	.199	.738	.604	SW...	SW...	SW...	4	4	12	6.7	S. 45 W	3	3	5	.....	.....
.547	.182	.698	.476	W.....	W.....	W	4	12	2	6.0	West..	3	3	2	.....	.....
.816	.607	.816	.746	SW...	W.....	W	12	25	2	12.0	S. 77 W	7	10	7	.....	.....
.860	.617	.872	.783	N.....	N.....	NW...	2	4	2	2.7	N. 10 W	3	4	1	.....	.....
1.000	.459	.794	.751	NW...	N. NE.	N.....	2	2	2	1.9	North .	0	3	3	.....	.....
.883	.521	.744	.716	W.....	W.....	W	4	4	2	3.3	West..	1	1	3	.....	.....
.876	.598	.811	.762	N. NW	SW...	SW...	2	2	2	1.3	S. 76 W	1	1	2	.....	.....
.750	.455	.853	.686	S.....	SE....	E. SE .	2	4	2	2.3	S. 40 E	4	3	5	.....	.....
.120	.675	.850	.548	SE....	E.....	NE ...	2	4	12	5.0	N. 60 E	0	0	10	.....	.....
.856	.675	.822	.782	S.....	SE....	NE ...	2	12	25	9.0	N. 74 E	6	3	10	.....	.22
.867	.505	.847	.740	S.....	S. SW.	W	4	35	12	14.7	S. 35 W	10	01	10	.....	.29
.738	.543	.907	.729	NW...	NW...	NW...	4	12	4	6.7	N. 45 W	10	8	9	.....	.02
.732	.617	.820	.723	N.....	NE....	NE ...	2	4	4	3.0	N. 36 E	10	10	10	.....	.....
.907	.669	.910	.829	E.....	E.....	E.....	2	12	4	6.0	East...	10	10	10	.....	.09
.829	.797	.754	.793	W.....	N. N W	N. NW	4	25	12	13.0	N. 43 W	10	9	8	.....	.16
1.000	.682	.834	.839	NW...	W. NW	W	12	12	25	15.3	N. 73 W	2	10	10	.....	.16
.800	.558	.793	.717	.....	.....	.....	....	....	....	4.3	S. 83 W	4.3	4.5	5.3	.....	1.47
.734	.529	.880	.714	S.....	S.....	S	12	25	4	13.7	South .	10	5	10	.....	.....
.883	.379	.887	.716	W.....	SW...	SW...	12	4	2	5.7	S. 75 W	10	7	3	.....	.16
.738	.537	.800	.692	W.....	W.....	NW...	4	25	12	12.7	N. 77 W	9	5	5	.....	.....
.823	.644	.860	.776	NW...	SW...	SW...	2	4	12	5.3	S. 52 W	3	3	5	.....	.....
.803	.582	.836	.740	SW...	SW...	SW...	25	12	4	13.7	S. 45 W	10	10	10	.....	.01
.807	.515	.628	.650	W.....	W.....	W	12	35	45	30.7	West..	10	5	5	.....	.07
.807	.794	.834	.812	N.....	W. NW	W. NW	35	45	4	23.3	N. 40 W	5	8	5	.....	.....
.712	.644	.807	.721	NW...	NW...	NW...	35	25	12	24.0	N. 45 W	4	5	5	.....	.....
.850	.628	.797	.758	S.....	W.....	N.....	2	12	2	4.0	West .	9	7	10	.....	.....
.843	.636	.775	.751	N.....	NW...	NW...	2	2	2	1.7	N. 29 W	10	5	6	.....	.....
.887	.665	.872	.808	NE....	NE ...	NE ...	4	12	25	13.7	N. 45 E	10	10	10	.....	.10
.899	.804	.892	.865	N.....	NE ...	NE ...	25	35	12	22.3	N. 30 E	10	10	5	.....	.12
.859	.671	.671	.734	N.....	N.....	E.....	2	2	4	2.0	N. 45 E	6	7	4	.....	.....
.804	.746	.790	.780	E.....	NE ...	NE ...	2	12	12	8.7	N. 47 E	9	7	10	.....	.....
.829	.665	.834	.776	W.....	W.....	W	4	12	2	6.0	West..	1	4	10	.....	.....
.845	.782	.754	.794	S.....	NE ...	NE ...	2	4	4	2.3	N. 58 E	4	10	10	.....	.....
.761	.792	.792	.782	NW...	NW...	NW...	2	12	2	5.3	N. 45 W	10	10	10	.....	.....
.890	.628	.685	.734	NW...	NW...	N.....	4	2	4	3.0	N. 27 W	10	4	1	.....	.....
.707	.788	.872	.789	NE....	NE ...	NE ...	4	4	25	11.0	N. 45 E	2	3	9	.....	.....
.782	.712	.792	.762	W.....	W	W	2	12	4	6.0	West .	10	10	10	.....	.20
.761	.712	.802	.758	NE....	NE ...	NE ...	4	25	2	10.3	N. 45 E	10	10	10	.....	.....
.756	.712	.843	.770	W.....	W.....	W	12	35	25	24.0	West..	10	4	10	.....	.23
.883	.510	.880	.758	NW...	NE ...	SE....	12	4	12	1.3	N. 45 E.	10	5	4	.....	.....
.788	.912	.792	.834	S.....	S.....	S.....	4	2	4	3.3	South .	10	4	3	.....	.....
.816	.638	.781	.745	E.....	SE....	W	2	12	2	4.0	S. 45 E	10	10	5	.....	.05
.748	.645	.719	.704	S.....	S. SW.	E.....	4	2	2	2.0	S. 13 E	1	9	9	.....	.24
.752	.599	.685	.679	W.....	W	W	25	12	12	16.3	West..	10	5	10	.....	.12
.703	.550	.782	.678	W.....	W	N. NW	4	4	12	5.7	N. 48 W	9	4	8	.....	.15
.746	.675	.864	.762	NW...	NW...	NW...	25	25	12	20.7	N. 45 W	4	4	0	.....	.....
.804	.761	.829	.798	NW...	W	W	12	2	2	5.0	N. 55 W	7	1	1	.....	.....
.850	.788	.880	.839	NE....	NE ...	NE ...	12	25	35	24.0	N. 45 E	2	10	10	.....	.....
.802	.666	.804	.757	.....	.....	.....	....	....	....	4.9	N. 49 W	7.6	6.5	6.9	.....	1.45

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Jan. 1	29.601	29.676	29.693	29.657	18	20	9	19	22	10	17.0	23	10	.087	.085	.054	.075
2	29.665	29.525	29.495	29.562	1	19	12	2	21	13	12.0	23	2	.023	.080	.063	.055
3	29.501	29.393	29.400	29.431	5	26	18	6	29	19	18.0	30	6	.043	.106	.087	.079
4	29.560	29.383	29.304	29.416	19	30	27	20	35	29	28.0	35	17	.092	.109	.124	.108
5	28.960	28.810	28.973	28.914	27	32	28	29	36	30	31.7	36	29	.124	.129	.130	.128
6	29.153	29.158	29.285	29.199	28	23	24	29	25	25	26.3	30	24	.142	.100	.117	.120
7	29.373	29.345	29.314	29.344	21	25	17	22	28	19	23.0	29	19	.101	.100	.071	.091
8	29.081	29.095	29.170	29.115	12	22	19	13	24	21	19.3	32	10	.063	.095	.080	.079
9	29.116	28.992	28.937	29.015	21	24	21	22	27	23	24.0	28	23	.101	.095	.090	.095
10	28.853	28.874	28.945	28.891	23	25	19	24	28	20	24.0	28	20	.112	.100	.092	.101
11	29.121	29.215	29.390	29.242	16	20	12	17	22	13	17.3	23	13	.078	.085	.063	.075
12	29.642	29.649	29.486	29.592	6	22	19	7	25	20	17.3	20	5	.046	.084	.092	.074
13	29.041	29.023	29.166	29.077	22	27	27	23	28	28	26.3	29	18	.107	.136	.136	.126
14	29.230	29.229	29.108	29.189	23	27	20	24	29	21	24.7	29	20	.112	.124	.096	.111
15	29.360	29.500	29.496	29.452	10	24	14	11	26	15	17.3	29	11	.057	.106	.071	.078
16	29.318	29.160	29.098	29.192	22	27	24	23	29	26	26.0	29	15	.107	.124	.106	.112
17	29.305	29.406	29.561	29.424	4	7	17	5	8	18	10.3	26	4	.041	.048	.063	.057
18	29.652	29.576	29.599	29.606	15	16	13	16	18	14	16.0	18	14	.074	.067	.067	.069
19	29.493	29.359	29.275	29.376	3	20	4	4	22	5	10.3	22	3	.038	.095	.041	.058
20	29.022	28.777	28.748	28.849	9	18	19	10	19	20	16.3	20	-2	.054	.087	.092	.078
21	28.736	28.863	29.038	28.879	19	26	19	20	28	20	22.7	28	19	.092	.117	.092	.100
22	29.244	29.320	29.386	29.317	17	25	21	18	27	22	22.3	28	16	.083	.112	.101	.099
23	29.496	29.523	29.599	29.539	19	23	20	20	25	21	22.0	25	19	.092	.100	.096	.096
24	29.713	29.648	29.631	29.664	19	26	22	20	28	23	23.7	28	19	.092	.117	.107	.105
25	29.285	28.815	28.773	28.958	22	30	37	23	32	38	31.0	38	22	.107	.144	.207	.152
26	28.908	29.223	29.053	29.061	25	26	24	26	28	25	26.3	38	24	.123	.117	.117	.119
27	29.269	29.306	29.484	29.353	12	17	14	13	19	15	15.7	28	12	.063	.071	.071	.068
28	29.537	29.464	29.434	29.478	11	18	11	12	19	12	14.3	20	10	.061	.087	.061	.070
29	29.537	29.632	29.530	29.566	4	16	10	5	18	11	11.3	18	3	.041	.067	.057	.055
30	29.709	29.631	29.477	29.606	-2	19	15	-1	21	16	12.0	25	-2	.028	.080	.074	.061
31	29.329	29.288	29.135	29.251	29	38	43	30	41	45	38.7	45	16	.149	.190	.251	.197
Means....	29.316	29.286	29.289	29.297	15.5	23.2	19.3	16.4	25.4	20.5	20.8	45	-2	.082	.102	.096	.093
Feb. 1	29.222	29.231	29.224	29.226	26	37	29	38	40	31	36.3	49	31	.186	.161	.137	.135
2	28.857	28.557	21.534	28.649	29	38	39	30	40	41	37.0	42	25	.149	.203	.212	.188
3	28.688	28.785	28.963	28.812	29	30	29	30	32	30	30.7	41	30	.149	.144	.149	.147
4	29.032	28.790	28.855	28.892	21	33	35	22	35	36	31.0	36	21	.101	.162	.191	.151
5	29.072	29.262	29.422	29.252	30	35	30	31	38	32	33.7	40	30	.155	.165	.144	.155
6	29.426	29.579	29.639	29.548	27	30	22	28	33	24	28.3	34	24	.136	.132	.095	.121
7	29.663	29.602	29.519	29.595	24	42	26	25	49	28	34.0	49	22	.117	.175	.117	.136
8	29.423	29.239	29.101	29.254	34	41	41	35	46	43	41.3	48	32	.183	.192	.231	.202
9	29.046	28.933	29.192	29.057	29	26	19	30	27	20	25.7	43	20	.149	.129	.092	.123
10	29.628	29.842	30.034	29.835	7	15	6	8	16	7	10.3	20	6	.048	.074	.046	.056
11	29.941	29.789	29.741	29.824	9	36	33	10	36	35	27.0	37	2	.054	.212	.162	.143
12	29.756	29.672	29.649	29.692	34	40	41	36	45	43	41.3	48	30	.170	.182	.231	.194
13	29.492	29.388	29.336	29.405	43	49	52	45	52	54	50.3	54	42	.251	.308	.349	.303
14	29.522	29.516	29.614	29.551	36	33	32	37	35	33	35.0	54	33	.199	.162	.169	.176
15	29.592	29.510	29.293	29.465	32	32	45	33	34	46	37.7	50	31	.168	.155	.208	.203
16	29.082	29.085	29.288	29.152	46	47	38	48	54	40	47.3	54	40	.284	.231	.203	.239
17	29.445	29.484	29.459	29.463	32	45	34	34	49	36	39.7	50	33	.155	.247	.170	.191
18	29.304	29.194	29.321	29.273	34	48	38	36	57	40	44.3	59	33	.170	.217	.202	.197
19	29.487	29.421	29.284	29.397	30	31	29	32	35	30	32.3	40	30	.144	.128	.149	.140
20	29.021	29.229	29.314	29.188	27	30	29	27	32	30	29.7	38	27	.147	.144	.149	.147
21	29.008	29.063	29.372	29.148	29	29	29	31	31	30	30.7	34	30	.137	.137	.149	.141
22	29.571	29.567	29.546	29.561	28	28	27	29	30	28	29.0	30	28	.142	.130	.135	.136
23	29.127	28.911	28.832	28.957	32	40	46	33	43	48	41.3	48	27	.168	.208	.284	.220
24	29.175	29.286	29.425	29.295	31	36	26	33	38	27	32.7	48	27	.151	.186	.129	.155
25	29.450	29.402	29.417	29.423	22	30	24	24	32	26	27.3	37	22	.095	.144	.106	.115
26	29.593	29.682	29.694	29.656	27	40	29	28	44	30	34.0	44	24	.136	.195	.149	.160
27	29.795	29.736	29.664	29.732	23	46	35	24	51	37	37.3	54	23	.119	.245	.178	.180
28	29.490	29.496	29.319	29.435	34	47	44	35	52	46	44.3	60	33	.183	.257	.262	.234
Means....	29.354	29.330	29.359	29.348	29.1	36.2	32.4	30.4	39.5	34.0	34.6	60	2	.151	.180	.174	.168

the northern and northwestern lakes at Cleveland, Ohio.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.845	.721	.791	.786	W	W	Calm..	2	4	0	2.0	West...	10	5	0	.....	.....
.460	.712	.810	.661	S	S	SE....	2	4	2	2.7	S. 10 E.	6	3	0	.....	.....
.760	.665	.845	.757	S	S	S	12	12	2	8.7	South ..	0	0	0	.....	.....
.850	.537	.775	.721	S	S	S	2	4	2	2.7	South ..	5	10	0	.....	.....
.775	.610	.782	.722	SE....	SW ...	W.NW	2	4	12	4.0	N. 87 W	10	10	10	.....	.....
.887	.746	.872	.835	W	W	W	4	12	35	17.0	West...	10	10	10	.....	.19
.860	.655	.692	.736	W	W	S	4	4	2	3.0	S. 77 W	10	6	0	.....	.04
.810	.738	.712	.753	S	NE ...	S	2	4	2	1.0	S. 67 E.	10	10	10	.....	.....
.860	.644	.730	.745	S	S	S	4	2	2	2.7	South ..	10	4	10	.....	.07
.868	.655	.850	.791	W	W	W	4	2	2	2.7	West ..	3	10	10	.....	.....
.834	.721	.810	.788	W	W	S	4	2	2	2.3	S. 73 W	10	6	0	.....	.08
.769	.622	.850	.747	SE....	NE ...	SE....	2	2	4	2.0	S. 62 E	0	10	10	.....	.....
.864	.883	.883	.877	SE....	NW ..	S	4	12	2	2.3	N. 58 W	10	10	10	.....	.46
.868	.775	.855	.833	S	NE ...	N	2	4	2	1.3	N. 45 E	10	10	10	.....	.....
.797	.754	.823	.791	N	W	SW ...	2	4	2	2.0	N. 82 W	3	0	4	.....	.....
.864	.775	.754	.798	S	SW ...	W	2	4	35	12.7	S. 83 W	10	10	10	.....	.24
.750	.777	.840	.789	NW ..	NW ...	NW ...	25	25	35	28.3	N. 45 W	10	10	10	.....	.....
.829	.682	.816	.776	W.NW	W	NW ...	12	4	2	6.0	N. 70 W	10	10	4	.....	.23
.740	.738	.750	.743	SW ..	SW ...	SW ...	2	4	2	2.7	S. 45 W	3	0	0	.....	.21
.791	.845	.850	.829	NE ...	NE ...	NE ...	2	12	2	5.3	N. 45 E.	10	10	10	.....	.....
.850	.768	.850	.823	NW ..	W.NW	W	2	12	12	9.0	N. 77 W	10	10	10	.....	.51
.840	.761	.860	.820	W	W	W	4	12	2	6.0	West...	10	6	10	.....	.24
.850	.746	.855	.817	NW ..	NW ...	NW ...	2	2	2	2.0	N. 45 W	10	10	10	.....	.16
.850	.768	.864	.827	W	W	NE ...	2	2	2	1.0	N. 62 W	10	10	10	.....	.....
.864	.794	.905	.854	SE....	SE....	SE....	4	12	12	9.3	S. 45 E.	10	10	10	.....	.....
.876	.768	.872	.839	SW ..	SW ...	SW ...	25	45	35	35.0	S. 45 W	10	10	10	.....	.19
.810	.692	.823	.775	W. SW	W.SW	W	12	35	35	27.0	S. 77 W	10	10	10	.....	.04
.804	.845	.804	.818	SW ...	SW ...	W	2	4	25	10.0	S. 82 W	10	10	10	.....	.....
.750	.682	.797	.743	SW ...	SW ...	SW ...	4	4	2	3.3	S. 45 W	10	6	10	.....	.....
.683	.712	.829	.741	S	S	S	4	4	12	6.7	South ..	3	0	10	.....	.....
.890	.738	.840	.823	S	S	S	2	2	45	16.3	South ..	0	10	10	.....	.26
.811	.727	.819	.786	.....	.....	.....	....	....	....	4.8	S 68 W	7.8	7.3	7.3	.....	2.92
.811	.732	.788	.777	W.SW	NW ...	S	2	2	2	1.3	S. 70 W	10	10	0	.....	.....
.890	.820	.824	.845	NE ..	SE ..	SE....	2	25	12	12.3	S. 48 E	10	10	10	.....	.....
.890	.794	.890	.858	SW ...	W.NW	W.NW	12	4	12	8.0	S. 85 W	10	10	10	.....	.21
.860	.797	.900	.852	SE....	SE....	SE....	4	4	35	14.3	S. 45 E	4	10	10	.....	.08
.893	.719	.794	.802	SW ...	SW ...	SW ...	12	2	5	5.3	S. 45 W	10	7	0	.....	.39
.883	.703	.738	.775	SW ...	W	S	12	25	2	11.7	S. 72 W	4	3	0	.....	.....
.872	.505	.768	.715	SE....	SE....	SE....	2	4	2	2.7	S. 45 E	0	0	0	.....	.....
.898	.617	.833	.783	SE..	SE....	SE....	12	4	2	6.0	S. 45 E.	0	10	10	.....	.....
.890	.880	.850	.873	W	N	NW ...	12	25	45	24.0	N. 38 W	10	10	10	.....	.22
.777	.829	.769	.792	NW ..	W	S	25	4	2	7.0	N. 41 W	8	3	0	.....	.58
.791	1.000	.797	.863	S	S	S	4	2	12	6.0	South ..	4	3	10	.....	.....
.802	.607	.833	.747	S	S	S	4	12	2	6.0	South ..	10	6	5	.....	.....
.840	.794	.805	.813	SE....	SE....	SE....	12	35	12	19.7	S. 45 E	10	7	10	.....	.10
.903	.797	.893	.864	NE ...	NE ...	NE ...	2	4	4	3.3	N. 45 E	10	10	10	.....	.26
.893	.792	.921	.869	NE ...	NE ...	SE	4	4	12	5.0	S. 79 E.	10	10	10	.....	.....
.850	.552	.820	.741	W	SW ...	W.SW	12	35	35	26.3	S. 61 W	10	0	4	.....	.45
.792	.710	.802	.768	W	W	W	2	2	2	2.0	West...	0	0	0	.....	.....
.802	.465	.820	.696	SE....	S. SW	W	4	25	2	9.0	S. 19 W	5	6	0	.....	.....
.794	.628	.890	.771	NE ..	NE ..	NE ...	4	12	12	9.3	N. 45 E	10	10	10	.....	.....
1.000	.794	.890	.895	NE ..	NE ..	NE ...	35	12	2	16.3	N. 45 E	10	10	10	.....	.28
.788	.788	.890	.822	N	N	N	25	35	25	28.3	North ..	10	10	10	.....	.....
.887	.782	.883	.851	NW ..	NW ..	S	4	4	12	3.0	S. 40 W	10	10	10	.....	.81
.893	.750	.850	.831	S	S	S	25	12	25	20.7	South ..	10	10	10	.....	.....
.800	.811	.880	.830	W	NW ..	NE ...	12	4	2	4.7	N. 70 W	10	10	10	.....	.07
.738	.794	.754	.762	N	N. NE	SE....	2	4	2	1.7	N. 35 E	7	3	0	.....	.....
.883	.677	.890	.817	NW ..	W.NW	W	4	4	2	3.3	N. 63 W	4	1	0	.....	.....
.868	.653	.807	.776	S	W.NW	S	2	2	2	1.3	S. 26 W	0	0	0	.....	.....
.898	.660	.843	.800	S	N	S	4	2	2	1.3	South ..	0	8	10	.....	.....
.853	.730	.837	.807	.....	.....	.....	....	....	....	1.2	S. 28 W	7.0	6.7	6.0	.....	3.45

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
	7 a. m.	2. p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
March 1	29.108	28.922	28.805	28.945	40	53	55	42	56	57	51.7	57	41	.221	.363	.407	.330
2	28.983	29.166	29.374	29.174	35	31	19	37	34	21	30.7	57	21	.178	.139	.080	.132
3	29.369	29.151	29.021	29.180	18	22	24	19	24	25	22.7	25	16	.087	.095	.117	.100
4	29.223	29.322	29.452	29.332	24	27	24	25	29	26	26.7	33	24	.117	.124	.106	.116
5	29.630	29.707	29.746	29.695	25	33	25	26	36	26	27.3	37	24	.123	.149	.123	.132
6	29.683	29.519	29.318	29.507	23	33	29	24	35	31	30.0	35	22	.112	.162	.137	.137
7	29.198	29.452	29.642	29.431	30	32	26	31	35	28	31.3	36	28	.155	.142	.117	.138
8	29.751	29.632	29.587	29.657	20	36	26	22	40	28	30.0	40	19	.085	.169	.117	.121
9	29.527	29.514	29.541	29.527	27	39	30	28	42	32	34.0	44	23	.136	.199	.144	.160
10	29.177	28.963	29.015	29.052	37	44	48	39	46	49	44.7	53	32	.194	.262	.322	.259
11	29.423	29.452	29.430	29.402	34	42	32	35	42	33	36.7	49	33	.183	.267	.168	.206
12	29.225	29.235	29.310	29.257	30	31	31	31	33	32	32.0	34	31	.155	.151	.162	.156
13	29.273	29.285	25.502	29.353	29	30	15	30	32	16	26.0	33	16	.149	.144	.074	.122
14	29.568	29.615	29.653	29.612	9	18	12	10	20	13	14.3	33	9	.054	.076	.063	.064
15	29.733	29.725	29.665	29.708	9	27	21	10	30	22	20.7	32	7	.054	.113	.101	.089
16	29.458	29.251	29.040	29.250	21	32	28	23	34	29	28.7	35	27	.090	.155	.142	.129
17	29.081	29.225	29.406	29.237	24	25	13	25	27	14	22.0	30	14	.117	.112	.067	.099
18	29.500	29.442	29.438	29.460	9	30	20	10	32	21	21.0	32	6	.054	.144	.086	.098
19	29.533	29.522	29.605	29.553	15	37	24	16	40	26	27.3	41	10	.074	.181	.106	.120
20	29.564	29.537	29.454	29.518	25	39	32	26	42	34	34.0	42	19	.123	.199	.155	.159
21	29.320	29.239	29.194	29.251	34	34	32	35	36	34	35.0	37	34	.183	.170	.155	.169
22	29.283	29.337	29.450	29.357	33	37	31	34	39	33	35.3	39	33	.175	.194	.151	.173
23	29.501	29.480	29.446	29.476	31	40	34	33	42	36	37.0	44	33	.151	.221	.170	.181
24	29.331	29.212	29.320	29.288	36	39	38	38	41	39	39.3	45	35	.286	.212	.217	.305
25	29.538	29.615	29.683	29.612	33	37	27	32	40	28	33.3	41	28	.....	.181	.136	.159
26	29.666	29.483	29.193	29.447	25	30	30	26	32	31	29.7	35	31	.123	.144	.155	.141
27	29.041	29.096	29.169	29.102	32	31	27	33	33	28	31.3	36	28	.168	.151	.136	.152
28	29.283	29.308	29.328	29.306	25	37	29	26	40	30	32.0	42	23	.123	.181	.149	.151
29	29.386	29.362	29.297	29.348	26	42	34	27	46	35	36.0	46	25	.129	.215	.183	.176
30	29.315	29.232	29.217	29.255	30	45	38	32	50	40	40.7	52	30	.144	.234	.203	.194
31	29.222	29.135	28.913	29.090	37	47	45	39	58	47	46.3	57	33	.194	.244	.273	.237
Means....	29.384	29.359	29.358	29.367	26.6	34.8	29.0	27.9	27.4	30.4	31.9	57	6	.134	.177	.152	.153
April 1	28.869	28.938	28.993	28.933	33	45	42	35	49	44	42.7	50	33	.162	.247	.241	.217
2	29.252	29.354	29.430	29.345	35	48	37	37	52	39	42.7	54	35	.178	.282	.194	.218
3	29.520	29.426	29.392	29.446	35	58	51	37	64	54	51.7	66	30	.178	.403	.335	.305
4	29.171	29.102	29.078	29.117	55	57	54	58	61	56	58.3	61	51	.393	.412	.391	.399
5	28.913	28.951	29.059	28.974	35	39	31	37	41	33	37.0	42	33	.178	.212	.151	.180
6	29.285	29.247	29.190	29.241	30	44	42	32	51	44	42.3	52	30	.144	.196	.241	.194
7	29.252	29.269	29.320	29.280	45	51	41	47	56	48	50.3	58	42	.273	.308	.166	.249
8	29.275	29.370	29.517	29.387	45	47	38	51	50	40	47.0	57	40	.220	.283	.203	.235
9	29.597	29.537	29.387	29.507	33	44	39	35	48	41	41.3	54	32	.162	.236	.212	.203
10	29.185	29.158	29.122	29.155	38	35	37	40	37	38	38.3	51	36	.203	.178	.207	.229
11	29.280	29.372	29.323	29.325	30	43	34	32	48	36	38.7	50	32	.144	.212	.170	.175
12	29.282	29.227	29.210	29.240	31	57	45	34	59	47	46.7	61	28	.139	.439	.273	.284
13	29.312	29.364	29.354	29.343	38	60	52	40	65	54	53.0	68	37	.203	.451	.362	.339
14	29.412	29.320	29.223	29.318	50	71	59	54	77	63	64.7	77	47	.318	.678	.447	.478
15	29.196	29.118	29.090	29.135	54	57	56	58	61	59	59.3	63	58	.365	.412	.409	.395
16	28.951	28.978	29.136	29.022	47	42	40	49	45	42	45.3	59	42	.297	.228	.221	.249
17	29.323	29.425	29.467	29.405	40	53	44	42	60	46	49.3	63	39	.221	.310	.262	.264
18	29.630	29.553	29.571	29.585	37	48	40	40	52	42	44.7	54	35	.181	.282	.221	.228
19	29.430	39.369	29.250	29.350	40	51	50	44	55	53	50.7	58	38	.195	.321	.321	.279
20	29.098	28.973	29.111	29.061	58	58	46	61	67	48	58.7	72	48	.443	.363	.224	.343
21	29.187	29.204	29.101	29.164	42	54	49	45	58	52	51.7	61	43	.228	.365	.308	.300
22	28.700	28.976	29.180	28.952	40	42	37	43	43	39	41.7	54	39	.208	.254	.194	.219
23	29.396	29.448	29.485	29.443	35	40	36	37	44	38	39.7	50	34	.178	.195	.186	.186
24	29.421	29.416	29.524	29.454	38	38	36	40	40	38	39.3	42	37	.203	.203	.186	.197
25	29.563	29.432	29.445	29.480	37	50	45	40	56	48	48.0	58	37	.181	.282	.260	.241
26	29.403	29.250	29.108	29.254	41	61	51	45	65	57	55.7	67	39	.203	.483	.295	.327
27	29.278	29.483	29.488	29.416	40	42	31	42	47	34	41.0	57	34	.221	.208	.139	.189
28	29.476	29.433	29.305	29.405	30	47	40	32	52	43	42.3	54	27	.144	.257	.208	.203
29	29.214	29.153	29.125	29.164	48	60	60	51	66	63	60.0	67	39	.296	.439	.478	.404
30	29.167	29.115	29.133	29.138	51	61	45	55	65	48	56.0	68	48	.321	.483	.260	.355
Means....	29.268	29.265	29.276	29.268	40.4	50.1	43.6	43.1	54.1	46.2	47.8	77	27	.296	.320	.261	.292

the northern and northwestern lakes at Cleveland, Ohio.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.829	.809	.874	.837	S	S	S	2	12	2	5.3	South ..	7	10	10	.....	.....
.807	.712	.712	.744	W	N. NE	N. NE.	25	4	25	10.0	N.27 W	10	10	10	.....	.06
.845	.738	.872	.818	NE ...	NE ...	NE ...	4	12	2	6.0	N. 45 E.	10	10	10	.....	.....
.872	.775	.754	.800	W	W	S	4	4	2	3.0	S. 13 W.	10	10	10	.....	.49
.876	.705	.876	.819	W	W	S	2	4	2	2.3	S. 73 W.	10	2	10	.....	.....
.868	.797	.788	.788	NE ...	NE ...	NE ...	4	4	2	3.3	N. 45 E.	10	10	10	.....	.....
.893	.698	.768	.786	NE ...	W.NW	SE....	4	25	2	7.3	N.59 W.	10	5	0	.....	.32
.721	.645	.768	.711	SE....	NE ...	SE....	2	4	2	1.9	East ...	6	7	0	.....	.....
.883	.744	.794	.807	W	W.NW	NE ...	2	4	2	1.7	N.59 W.	6	0	10	.....	.....
.816	.843	.926	.862	S	S	W	12	25	25	15.0	S. 34 W.	10	10	10	.....	.....
.898	1.000	.893	.930	W	W.NW	NE ...	12	2	2	4.3	N.80 W.	10	10	10	.....	.12
.893	.800	.896	.863	NE ...	N.	NE ...	12	2	2	5.0	N. 39 E.	10	10	10	.....	.39
.890	.794	.829	.838	W	W	W	4	12	35	17.0	West ...	10	10	0	.....	.....
.791	.702	.810	.768	W	SW ..	S	12	4	2	5.0	S. 71 W.	10	5	0	.....	.18
.791	.675	.860	.775	W	SW ..	S	2	2	2	1.6	S. 45 W.	0	6	10	.....	.....
.730	.792	.887	.803	NE ...	NE ...	NE ...	4	4	2	3.3	N. 45 E	10	10	10	.....	.....
.872	.761	.816	.816	W.NW	W.NW	W	25	12	25	20.3	N.76 W.	10	3	0	.....	.41
.791	.794	.855	.813	SW ..	W	E	4	2	2	1.3	S. 45 W.	10	2	0	.....	.....
.829	.732	.754	.772	S. SE..	SE....	E. NE.	2	4	2	2.3	S. 57 E	0	0	3	.....	.....
.876	.744	.792	.804	NE ...	NE ...	NE ...	2	12	12	8.7	N. 45 E.	0	10	10	.....	.....
.898	.802	.792	.831	E. SE .	E. SE .	E	12	2	2	5.3	S. 69 E.	10	10	10	.....	.....
.875	.816	.800	.837	NE ...	NE ...	NE ...	2	2	2	2.0	N. 45 E	10	10	10	.....	.80
.800	.829	.802	.810	NE ...	NE ...	Calm..	2	4	0	2.0	N. 45 E	10	10	10	.....	.03
.811	.824	.907	.847	E. SE .	S	SW ..	2	25	12	11.7	S. 11 W.	10	10	10	.....	.....
.....	.732	.883	.808	W	W ..	N	12	4	2	5.3	N. 83 W.	10	0	0	.....	.15
.876	.794	.893	.854	SE ...	NE ...	SE....	2	4	2	1.9	East ...	10	10	10	.....	.....
.893	.800	.883	.859	NW ..	NW ..	NW ..	2	4	25	10.3	N. 45 W.	10	10	10	.....	.12
.876	.732	.890	.833	NW ..	W	S	2	25	2	8.7	S. 88 W.	0	0	0	.....	.10
.880	.691	.898	.823	SW ..	SW ..	SW .	12	25	4	13.7	S. 45 W.	0	3	4	.....	.....
.794	.646	.820	.753	W	W	Calm..	4	4	0	2.7	West ...	0	0	0	.....	.....
.816	.606	.847	.756	E. NE	N	E	2	2	2	1.3	N. 35 E	0	5	10	.....	.....
.844	.757	.836	.812	.....	.....	.....	....	....	....	2.5	N. 88 W.	7.4	6.7	6.7	.....	3.07
.797	.710	.836	.781	SW ..	W.SW	NW ..	12	12	25	12.7	N.83 W.	10	3	10	.....	.55
.807	.727	.816	.783	W.NW	W.NW	S	5	12	2	5.0	N. 74 W.	6	0	0	.....	.....
.807	.675	.802	.761	SE....	SE....	SE....	4	12	12	9.3	S. 45 E .	0	0	0	.....	.....
.816	.769	.872	.819	S.	S	S	25	12	2	13.0	South ..	10	10	10	.....	.....
.807	.824	.800	.810	W.....	W	W	12	25	35	24.0	West ...	10	10	10	.....	.34
.794	.525	.836	.718	W. SW	W. SW	S	4	2	4	3.0	S. 40 W.	3	9	0	.....	.14
.847	.687	.494	.676	SW .	W	S	12	2	2	5.0	S. 45 W.	6	8	4	.....	.....
.590	.786	.820	.732	S	NW ..	S	4	2	2	1.3	S. 40 W.	3	10	0	.....	.....
.797	.704	.824	.775	NE ...	NE ...	NE ...	2	4	4	3.3	S. 45 E	0	0	0	.....	.....
.820	.807	.905	.844	NE ...	NE ...	NE ...	2	12	4	6.0	N. 45 E.	10	10	10	.....	.05
.794	.631	.802	.742	N. NE	NW ..	S	4	2	2	1.0	N. 1 E..	0	0	0	.....	.65
.712	.878	.847	.812	S	NW ..	S	2	4	2	1.0	S. 67 W.	0	0	0	.....	.....
.820	.731	.867	.806	SE....	N	S	2	2	2	1.7	S. 45 E .	0	0	0	.....	.....
.738	.731	.776	.748	S	S	S	2	25	2	9.7	South ..	5	10	0	.....	.....
.756	.769	.819	.781	SW ..	SW ..	SW ..	25	25	2	17.3	S. 45 W.	7	10	0	.....	.04
.853	.762	.829	.815	NE ...	NE ...	N. NW	2	12	12	7.3	N. 14 E	10	10	10	.....	.15
.829	.599	.843	.757	NW ..	NW ..	S	2	2	2	1.0	N.75 W.	0	0	0	.....	.....
.732	.727	.829	.763	NE ...	NE ...	NE ...	2	4	2	2.7	N. 45 E.	0	0	4	.....	.....
.677	.743	.798	.739	S	NE ...	S	4	2	2	1.7	S. 16 E.	6	10	3	.....	.....
.825	.550	.850	.742	S	W	NW ..	2	12	12	7.3	N.72 W.	4	4	0	.....	.....
.762	.756	.794	.771	W	NW ..	NE ...	2	2	2	1.0	N.43 W.	3	5	10	.....	.....
.750	.916	.816	.861	NE ...	NW ..	N	12	4	2	5.0	N. 22 E.	10	10	10	.....	.91
.807	.677	.811	.765	NE ...	NE ...	N	4	12	4	6.3	N. 37 E	10	3	10	.....	.05
.820	.820	.811	.817	E	N.	SE....	4	2	2	2.0	N. 81 E.	10	10	10	.....	.....
.732	.627	.777	.712	SE....	NW ..	SE....	2	2	2	0.7	S. 45 E	0	6	0	.....	.08
.684	.783	.634	.700	S	S	S	2	4	12	6.0	South ..	0	3	10	.....	.....
.829	.624	.712	.722	N	N	S	12	2	2	4.0	North...	10	7	0	.....	.09
.794	.660	.750	.735	S	NE ...	SE....	2	12	2	3.7	N. 63 E	3	2	0	.....	.....
.790	.685	.831	.769	S	S	S	25	35	4	21.3	South ..	4	10	10	.....	.....
.743	.783	.777	.768	SE....	SW .	NE ...	2	2	4	0.9	East ...	10	5	10	.....	.20
.777	.722	.799	.766	.....	.....	.....	....	....	....	1.9	S. 44 W.	5.0	5.5	4.4	.....	3.25

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
May 1	29.069	29.193	29.203	29.155	38	50	43	40	54	46	46.7	60	39	.203	.308	.238	.250
2	29.451	29.558	29.563	29.524	35	44	31	37	49	34	40.0	52	34	.178	.223	.139	.180
3	29.648	29.641	29.510	29.600	29	50	40	30	55	42	42.3	56	28	.149	.295	.221	.222
4	29.358	29.244	29.168	29.257	48	66	60	51	72	63	62.0	72	41	.296	.559	.478	.444
5	29.197	29.231	29.234	29.221	58	52	57	60	58	59	59.0	66	55	.456	.296	.439	.397
6	29.237	29.212	29.217	29.222	45	49	42	47	52	45	48.0	60	45	.273	.308	.228	.270
7	29.203	29.207	29.221	29.210	40	48	41	42	52	44	46.0	56	41	.221	.282	.218	.240
8	29.149	29.085	29.081	29.105	40	50	42	42	55	45	47.3	55	41	.231	.295	.228	.248
9	29.069	29.061	29.053	29.061	45	56	50	49	64	53	55.3	68	42	.247	.343	.221	.304
10	29.180	29.176	29.199	29.185	50	56	50	52	63	53	56.0	68	48	.334	.356	.321	.337
11	29.312	29.402	29.372	29.362	44	60	49	47	66	53	55.3	71	43	.249	.438	.295	.327
12	29.450	29.422	29.380	29.417	46	55	52	49	62	55	55.3	65	42	.271	.340	.349	.320
13	29.129	29.006	28.908	29.014	50	64	58	52	67	60	59.7	72	49	.334	.556	.456	.449
14	28.939	29.009	29.014	28.987	47	46	44	49	49	46	48.0	60	46	.297	.271	.262	.210
15	28.892	29.016	29.109	29.004	44	51	48	46	55	51	50.7	57	44	.263	.321	.296	.293
16	29.166	29.101	29.197	29.155	44	55	49	47	60	51	52.7	63	43	.249	.367	.321	.312
17	29.260	29.395	29.470	29.375	48	50	46	50	55	49	51.3	58	45	.309	.295	.271	.292
18	29.573	29.555	29.505	29.544	45	60	50	47	64	53	54.7	70	38	.260	.465	.321	.349
19	29.440	29.327	29.207	29.325	47	53	48	50	63	50	54.3	61	46	.283	.270	.309	.287
20	29.185	29.265	29.190	29.213	46	50	47	48	53	49	50.0	58	47	.284	.321	.297	.301
21	28.884	28.723	28.737	28.781	53	56	53	55	59	55	56.3	64	47	.376	.409	.376	.387
22	28.653	28.864	28.952	28.823	44	45	43	46	47	45	46.0	55	45	.262	.273	.251	.262
23	28.997	29.061	29.126	29.061	42	45	44	44	48	46	46.0	50	42	.241	.260	.269	.254
24	29.260	29.219	29.214	29.231	44	58	54	47	67	57	57.0	70	42	.249	.363	.378	.330
25	29.136	29.016	29.128	29.093	50	59	52	53	62	55	56.7	65	47	.321	.460	.349	.377
26	29.170	29.220	29.302	29.231	47	57	49	50	63	51	54.7	69	47	.283	.386	.321	.330
27	29.370	29.417	29.365	29.384	45	59	51	47	59	51	52.3	63	40	.273	.500	.374	.382
28	29.270	29.135	29.118	29.174	48	70	59	51	77	63	63.7	79	40	.296	.639	.447	.457
29	29.208	29.173	29.334	29.238	64	64	56	67	70	59	65.3	75	59	.556	.516	.409	.494
30	29.400	29.349	29.346	29.365	51	60	51	54	66	55	58.3	73	52	.335	.438	.321	.365
31	29.494	29.504	29.440	29.479	48	55	49	51	60	53	54.7	67	46	.296	.367	.395	.319
Means ...	29.217	29.219	29.221	29.219	46.0	54.9	48.6	48.4	59.6	51.3	53.0	79	28	.286	.372	.316	.325
June 1	29.402	29.536	29.118	29.352	50	70	66	53	75	70	66.0	77	47	.321	.666	.822	.603
2	28.975	28.905	28.912	28.931	62	67	63	65	72	66	67.7	80	65	.516	.595	.536	.549
3	28.955	28.990	29.104	29.016	56	61	57	60	66	60	62.0	70	59	.396	.470	.426	.431
4	29.219	29.223	29.241	29.228	53	67	61	56	73	65	64.7	75	53	.363	.581	.463	.476
5	29.364	29.391	29.311	29.355	54	70	65	57	77	69	67.7	82	55	.378	.639	.564	.527
6	29.283	29.232	29.245	29.253	63	79	71	66	90	76	77.3	95	63	.536	.977	.691	.735
7	29.278	29.260	29.263	29.267	66	76	65	70	82	70	74.0	85	67	.586	.816	.550	.651
8	29.338	29.388	29.381	29.369	61	60	58	64	69	62	65.0	74	62	.497	.398	.429	.441
9	29.468	29.426	29.421	29.438	59	65	57	62	72	61	65.0	76	57	.460	.524	.412	.465
10	29.472	29.423	29.408	29.434	55	76	64	59	74	68	67.0	82	53	.380	....	.543	.462
11	29.428	29.378	29.308	29.371	60	75	71	64	85	74	74.3	87	59	.465	.733	.718	.639
12	29.358	29.378	29.398	29.378	67	73	67	70	79	70	73.0	86	70	.622	.730	.622	.658
13	29.445	29.420	29.415	29.427	64	70	68	67	79	71	72.3	83	62	.556	.612	.644	.604
14	29.391	29.347	29.315	29.351	65	76	71	69	87	77	77.7	91	66	.564	.748	.678	.663
15	29.253	29.225	29.210	29.229	66	71	70	69	75	73	72.3	78	68	.599	.704	.693	.665
16	29.323	29.308	29.335	29.322	68	70	67	71	78	71	73.3	83	69	.644	.625	.608	.626
17	29.371	29.257	29.237	29.288	61	78	73	65	87	78	76.7	89	63	.483	.836	.744	.688
18	29.400	29.443	29.501	29.448	64	70	64	67	77	67	70.3	80	67	.556	.639	.556	.584
19	29.528	29.548	29.513	29.530	57	64	60	60	73	64	65.7	77	57	.426	.476	.465	.456
20	29.461	29.473	29.448	29.461	56	70	64	60	74	68	67.3	74	56	.396	.679	.543	.539
21	29.441	29.663	29.445	29.516	59	70	65	62	75	69	68.7	77	59	.460	.686	.564	.563
22	29.428	29.412	29.385	29.408	63	72	72	67	80	76	74.3	82	63	.522	.677	.731	.643
23	29.370	29.335	29.278	29.328	68	73	71	71	79	75	75.0	83	67	.644	.730	.704	.692
24	29.243	29.277	29.155	29.225	68	71	71	71	77	75	74.3	85	67	.644	.678	.704	.675
25	29.135	29.120	29.165	29.140	70	71	70	73	79	74	75.3	80	69	.693	.651	.679	.674
26	29.253	29.272	29.280	29.268	68	75	66	71	83	71	75.0	84	66	.644	.760	.572	.658
27	29.240	29.204	29.245	29.296	70	75	72	73	86	76	78.3	86	67	.693	.719	.731	.714
28	29.423	29.498	29.478	29.466	68	70	63	74	77	67	72.7	77	67	.604	.639	.522	.588
29	29.501	29.408	29.338	29.416	60	72	69	64	79	74	72.3	80	60	.465	.690	.641	.599
30	29.285	29.152	29.168	29.202	71	80	76	75	89	82	82.0	92	70	.704	.901	.816	.807
Means ...	29.334	29.330	29.301	29.322	61.7	71.2	66.6	65.8	78.3	70.9	71.6	95	47	.547	.674	.613	.608

the northern and northwestern lakes at Cleveland, Ohio.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.890	.738	.767	.775	N. NW	NW..	W	25	12	25	18.0	N. 54 W.	10	0	3	.....	.76
.807	.636	.712	.752	W	NW..	S	4	2	2	2.0	S. 82 W.	10	0	0	.....	.....
.890	.681	.829	.800	S	NE ...	NE ...	2	25	2	8.7	N. 49 E.	0	2	4	.....	.....
.790	.712	.831	.778	S	S	S	12	25	35	24.0	South ..	4	10	10	.....	.....
.880	.592	.878	.783	S	S	S	2	2	2	2.0	South ..	10	5	10	.....	.19
.847	.794	.762	.801	W.NW	W.NW	Calm..	12	12	0	8.0	N. 68 W.	10	7	10	.....	.21
.829	.727	.756	.771	NW ..	NW ..	N	2	4	12	5.7	N. 15 W.	10	6	10	.....	.02
.829	.681	.762	.757	N	NW ..	N	25	25	4	16.7	N. 21 W.	10	5	0	.....	.....
.710	.575	.798	.694	NW ..	NW ..	W	2	4	2	2.7	N. 58 W.	0	0	10	.....	.....
.861	.619	.798	.759	NW ..	W.NW	NW ..	2	12	2	5.0	N. 61 W.	6	3	0	.....	.....
.772	.685	.733	.730	W	W.NW	S	2	4	2	1.7	S. 82 W.	0	0	0	.....	.....
.781	.612	.805	.733	NE ...	NE ...	S	4	12	2	5.0	N. 51 E.	0	3	7	.....	.....
.861	.841	.880	.861	SE....	S	W	12	4	4	4.3	S. 20 E.	7	10	10	.....	.58
.853	.781	.843	.826	W.SW	W	S	12	12	2	8.0	S. 74 W.	10	10	10	.....	.49
.843	.743	.790	.792	W.NW	W	S	4	4	2	2.3	S. 86 W.	10	3	10	.....	.27
.772	.708	.859	.780	W	W.by N	S	4	4	2	2.7	S. 82 W.	0	10	4	.....	.....
.856	681	.781	.773	W.NW	W.NW	N	12	4	2	5.7	N. 61 W.	7	8	0	.....	.....
.777	.780	.798	.785	N.NW.	W.NW	S	2	2	2	1.0	N. 78 W.	0	0	5	.....	.....
.786	.470	.856	.704	S	E.....	NE	2	4	12	4.7	N. 63 E	8	10	10	.....	.....
.850	.798	.853	.834	NE ...	NE ...	.....	25	12	....	12.3	N. 45 E.	10	10	....	.....	.23
.869	.819	.869	.852	SE....	SE....	SE....	25	12	35	24.0	S. 45 E.	10	10	10	.....	.....
.843	.847	.840	.843	W	W	W	25	45	45	38.3	West...	10	10	10	.....	.46
.836	.777	.843	.819	W	W.NW	SW ..	25	12	2	12.7	N. 85 W.	10	10	5	.....	1.05
.772	.550	.812	.711	SE....	SW ..	S	2	4	2	2.3	S. 11 W.	0	5	0	.....	.12
.798	.828	.805	.810	S	S	S	12	25	2	13.0	South ..	10	10	10	.....	.....
.786	.670	.859	.772	N	N	S	2	4	2	1.3	North ..	7	0	0	.....	.13
.847	1.000	1.000	.949	NE ...	NE ...	NE ...	2	12	2	5.3	N. 45 E	3	10	10	.....	.....
.790	.689	.776	.752	E. NE	NE ...	W	2	12	2	4.3	N. 41 E.	10	6	10	.....	.35
.841	.704	.819	.788	SW ..	W	NW ..	2	4	4	3.0	N. 81 W.	3	5	10	.....	.16
.802	.685	.743	.743	W.NW	W	N	4	2	25	9.0	N. 12 W.	10	6	5	.....	.....
.790	.708	.733	.747	N	N. NW	S	4	2	2	1.3	N. 12 W.	0	3	0	.....	.....
.819	.714	.812	.782	.....	.....	.....	....	....	....	5.5	N. 23 W.	6.3	5.7	6.1	.....	5.02
.798	.768	.586	.717	NW ..	N. NW	S	2	2	4	1.0	S. 75 W.	2	3	6	.....	....
.836	.758	.838	.811	S	W	S	2	25	2	8.7	S. 80 W.	10	10	3	.....	.34
.765	.735	.822	.774	SW ..	W.NW	W.NW	12	2	5	5.3	S. 68 W.	10	9	0	.....	.39
.809	.716	.783	.769	S	SW ..	S	4	4	2	3.0	S. 18 W.	3	7	0	.....	.....
.812	.689	.796	.766	SE....	NE ...	NE ...	2	4	4	2.7	N. 61 E.	0	0	5	.....	.....
.838	.955	.771	.855	S. SE	NW ..	S	2	2	2	1.0	S. 12 W.	0	0	3	.....	.....
.799	.747	.551	.699	S	N. NE.	NE ...	2	4	2	1.3	N. 40 E.	4	9	10	.....	.....
.833	.564	.772	.723	NE ...	NE ...	Calm..	4	12	0	5.3	N. 45 E	6	5	0	.....	.....
.828	.668	.769	.755	NE ...	N	S	4	5	2	1.7	N. 34 E.	0	0	0	.....	.....
.761	.....	.793	.777	S	N. NE.	S	2	12	2	3.0	N. 31 E.	0	4	0	.....	.....
.780	.609	.856	.748	S	S	S	25	35	25	28.3	South ..	6	7	9	.....	.....
.848	.738	.848	.811	S. SW.	W.NW	N	2	2	25	8.3	N. 5 W	10	3	10	.....	.32
.841	.618	.850	.770	N	N	S	2	2	2	0.7	North ..	0	1	4	.....	.47
.796	.584	.731	.704	S	S. SW.	SW ..	2	12	2	5.3	S. 22 W.	0	6	3	.....	.....
.846	.812	.854	.837	S	S	S	12	25	12	16.3	South ..	10	10	10	.....	.12
.850	.653	.802	.768	W	N	Calm..	2	2	0	1.0	N. 45 W.	10	2	0	.....	.10
.783	.652	.776	.737	S	S	S	12	12	2	8.7	South ..	0	6	10	.....	.....
.841	.689	.841	.790	W	W.by N	Calm..	4	25	0	9.7	N. 81 W.	5	3	0	.....	.....
.822	.588	.780	.730	S	N	S	2	4	2	....	.....	0	0	0	.....	.....
.765	.810	.793	.789	E. SE.	NE ...	Calm..	2	4	0	1.7	N. 67 E	7	9	0	.....	.....
.828	.768	.796	.797	NE ...	N. NE.	N	4	4	2	3.3	N. 27 E.	0	0	0	.....	.....
.790	.661	.815	.755	S	NW ..	Calm..	2	4	0	1.0	N. 75 W.	0	0	0	.....	.....
.850	.738	.812	.800	S	NE ...	Calm..	12	2	0	3.7	S. 7 E..	4	6	0	.....	.....
.850	.731	.812	.798	S. SE	NE ...	N	4	4	2	1.7	N. 77 E.	0	9	0	.....	.....
.854	.657	.810	.774	S. SE	NE ...	S	2	4	2	1.3	S. 75 E.	0	6	3	.....	.....
.850	.673	.754	.759	W	W.NW	S	2	4	2	2.0	S. 8 W .	10	0	5	.....	.....
.854	.579	.815	.749	S	W	W. SW	2	12	12	8.0	S. 15 W.	4	7	4	.....	.....
.720	.689	.790	.733	W	N	S	4	4	2	1.7	N. 23 W.	5	3	0	.....	.10
.780	.697	.764	.717	S	N	S	2	4	4	0.7	South ..	0	2	0	.....	.....
.812	.660	.747	.740	SW ..	W. SW	W	12	25	12	15.7	S. 67 W.	0	4	3	.....	.....
.794	.697	.784	.765	.....	.....	.....	....	....	....	2.2	S. 37 W.	3.5	4.6	2.8	.....	1.84

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
July 1	29.278	29.312	29.308	29.299	65	70	66	69	76	69	71.3	83	69	.564	.652	.599	.605
2	29.361	29.312	29.315	29.329	61	71	72	65	79	76	73.3	81	63	.483	.651	.731	.622
3	29.308	29.274	29.232	29.271	69	76	73	72	84	77	77.7	86	72	.668	.729	.757	.718
4	29.192	29.154	29.135	29.160	71	71	70	75	77	73	75.0	86	73	.704	.678	.693	.692
5	29.190	29.130	29.084	29.135	69	72	71	72	78	74	74.7	81	71	.668	.704	.718	.697
6	29.155	29.202	29.258	29.205	69	71	69	72	77	73	74.0	79	72	.668	.678	.655	.667
7	29.280	29.300	29.338	29.306	70	75	68	74	80	72	75.3	81	68	.679	.840	.631	.703
8	29.411	29.398	29.423	29.411	60	66	66	63	75	69	69.0	76	61	.478	.519	.599	.532
9	29.428	29.481	29.453	29.454	60	65	61	62	70	64	65.3	71	61	.491	.550	.497	.513
10	29.494	29.431	29.345	29.423	54	66	68	57	74	71	67.3	76	53	.378	.532	.644	.518
11	29.320	29.272	29.258	29.283	67	75	70	73	85	73	77.0	86	73	.581	.733	.693	.669
12	29.325	29.325	29.491	29.380	63	64	62	67	68	65	66.7	78	65	.522	.543	.516	.527
13	29.496	29.505	29.533	29.511	60	65	61	62	70	64	65.3	71	60	.491	.550	.497	.513
14	29.523	29.480	29.468	29.490	58	70	71	62	79	74	71.7	81	56	.429	.612	.718	.586
15	29.375	29.342	29.348	29.355	65	70	67	69	74	70	71.0	80	66	.543	.679	.622	.615
16	29.455	29.475	29.471	29.467	61	67	61	66	70	65	67.0	74	63	.470	.622	.422	.525
17	29.536	29.508	29.491	29.512	59	63	62	63	71	67	67.0	71	54	.447	.489	.429	.468
18	29.521	29.475	29.466	29.487	58	66	62	60	72	66	66.0	72	56	.456	.559	.502	.506
19	29.438	29.443	29.436	29.439	59	70	58	61	75	62	66.0	76	58	.473	.666	.429	.556
20	29.481	29.465	29.401	29.449	61	70	65	63	74	67	68.0	74	57	.510	.679	.591	.595
21	29.375	29.338	29.253	29.322	66	72	68	68	79	72	73.0	79	62	.612	.690	.631	.644
22	29.255	29.255	29.215	29.242	66	76	69	69	81	75	75.0	81	63	.599	.829	.628	.685
23	29.280	29.300	29.315	29.298	65	77	69	70	81	74	75.0	82	66	.550	.873	.641	.688
24	29.323	29.309	29.244	29.292	68	79	75	73	84	81	79.3	84	68	.618	.922	.787	.776
25	29.210	29.139	29.110	29.153	74	76	70	76	83	76	78.3	85	74	.812	.802	.652	.755
26	29.145	29.180	29.208	29.178	68	71	69	72	76	73	73.7	78	73	.631	.691	.655	.659
27	29.208	29.194	29.164	29.189	66	71	72	69	78	78	75.0	81	67	.599	.664	.704	.656
28	29.180	29.129	29.148	29.152	73	78	70	76	85	73	78.0	86	73	.771	.863	.693	.776
29	29.320	29.410	29.431	29.387	65	64	62	68	70	65	67.7	75	65	.577	.516	.516	.556
30	29.498	29.518	29.476	29.497	65	62	61	68	70	64	67.3	71	56	.577	.449	.497	.508
31	29.396	29.338	29.265	29.333	57	70	67	61	77	70	69.3	78	58	.412	.639	.622	.558
Means ...	29.347	29.335	29.325	29.336	64.2	70.3	66.9	67.6	76.5	70.7	71.6	86	53	.563	.665	.610	.615
Aug. 1	29.221	29.178	29.128	29.176	61	70	67	65	74	70	69.7	76	63	.483	.679	.622	.595
2	29.155	29.248	29.290	29.231	63	70	65	66	75	69	70.0	75	66	.536	.666	.564	.589
3	29.395	29.458	29.468	29.440	62	66	64	65	73	68	68.7	73	65	.516	.545	.543	.535
4	29.531	29.532	29.518	29.527	60	71	68	64	79	72	71.7	80	59	.465	.651	.631	.582
5	29.560	29.550	29.500	29.537	64	71	70	67	80	73	73.3	82	63	.556	.637	.693	.629
6	29.490	29.454	29.467	29.470	65	76	72	69	83	76	76.0	84	67	.564	.802	.731	.699
7	29.460	29.434	29.412	29.435	68	70	68	71	70	74	71.7	80	68	.644	.733	.604	.660
8	29.420	29.304	29.332	29.352	68	70	71	72	79	75	75.3	80	68	.631	.612	.704	.649
9	29.348	29.347	29.327	29.374	65	74	72	69	79	77	75.0	80	67	.564	.772	.716	.685
10	29.525	29.450	29.468	29.481	68	70	62	71	75	72	72.7	78	72	.644	.666	.422	.577
11	29.520	29.552	29.453	29.508	72	68	65	75	76	71	70.7	76	63	.744	.577	.537	.619
12	29.386	29.292	29.124	29.267	60	71	74	63	80	79	74.0	81	62	.438	.637	.772	.616
13	29.145	29.120	29.168	29.144	71	72	69	76	77	72	75.0	80	72	.691	.718	.668	.692
14	29.300	29.465	29.385	29.383	65	67	64	69	73	68	70.0	74	67	.543	.581	.543	.556
15	29.421	29.405	29.388	29.405	62	67	65	65	74	70	69.7	74	62	.516	.568	.550	.545
16	29.358	29.318	29.275	29.317	65	68	70	70	76	73	73.0	77	63	.550	.577	.693	.607
17	29.255	29.187	29.129	29.190	61	75	75	65	82	82	76.3	85	62	.483	.773	.773	.676
18	29.214	29.243	29.194	29.217	71	77	72	78	89	78	81.7	89	75	.664	.765	.704	.711
19	29.330	29.342	29.328	29.333	65	70	69	68	76	72	72.0	79	68	.537	.652	.693	.619
20	29.338	29.372	29.365	29.365	67	67	64	70	72	68	70.0	73	68	.622	.595	.543	.587
21	29.476	29.330	29.285	29.364	58	67	65	61	73	69	67.7	73	60	.443	.581	.564	.529
22	29.268	29.238	29.222	29.243	58	70	66	60	74	70	68.0	75	60	.456	.679	.586	.574
23	29.196	29.160	29.142	29.166	60	70	72	62	78	77	72.3	79	60	.491	.625	.718	.611
24	29.228	29.308	29.360	29.299	70	66	65	73	74	68	71.7	78	68	.693	.539	.577	.603
25	29.471	29.465	29.458	29.465	60	67	64	62	71	67	66.7	72	57	.491	.608	.556	.552
26	29.436	29.368	29.338	29.381	59	70	71	62	75	75	70.7	77	60	.464	.686	.704	.618
27	29.318	29.199	29.144	29.220	67	75	76	70	84	79	77.7	86	69	.622	.746	.856	.741
28	29.135	28.919	29.162	29.072	70	72	70	76	79	74	76.3	80	74	.652	.694	.679	.674
29	29.213	29.260	29.331	29.268	61	65	59	66	73	63	67.3	75	61	.470	.510	.447	.476
30	29.494	29.556	29.541	29.530	52	57	52	57	65	57	59.7	66	56	.322	.359	.338	.339
31	29.424	29.248	29.181	29.284	49	61	60	53	70	64	62.3	70	49	.295	.416	.465	.392
Means ...	29.356	29.332	29.319	29.336	63.4	69.3	67.3	67.1	76.1	71.3	71.5	89	49	.541	.634	.618	.598

the northern and northwestern lakes at Cleveland, Ohio.

VAPOR.				WIND.							Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.769	.727	.846	.781	N.....	N.....	Calm..	4	2	0	2.0	North..	3	4	0	.....	.....
.783	.657	.815	.752	S.....	N. NE.	S. SE..	2	2	2	1.0	S. 32 E.	0	0	0	.....	.....
.852	.677	.817	.782	SW ..	W	S. SE..	4	4	2	2.7	S. 35 W.	10	4	0	.....	.02
.812	.731	.854	.799	SW...	SW ..	Calm..	4	4	0	2.7	S. 45 W.	7	10	10	.....	.....
.852	.734	.856	.814	S.....	S.....	S.....	2	4	2	2.7	South..	6	8	4	.....	.51
.852	.731	.807	.797	NW ..	NW ..	S.....	4	12	2	5.0	N. 51 W.	10	4	3	.....	.51
.810	.782	.804	.799	SW...	NW ..	N	12	12	2	6.0	N. 83 W.	8	3	4	.....	.....
.831	.599	.846	.759	S.....	N.....	S.....	4	12	2	2.0	North..	0	5	3	.....	.....
.884	.751	.833	.823	NW ..	W. NW	S. SE..	12	12	2	7.3	N. 59 W.	4	4	0	.....	.57
.812	.634	.850	.732	S	S.....	S.....	12	12	2	8.7	South..	7	6	0	.....	.....
.716	.609	.854	.726	S. SE.	S.....	W	25	12	4	12.0	S. 9 E..	0	7	10	.....	.....
.790	.793	.836	.806	N.....	N.....	N.....	12	4	12	9.3	North..	10	8	5	.....	.37
.884	.751	.833	.823	NE ..	NE...	S.....	2	12	2	4.0	N. 49 E.	0	0	0	.....	.....
.772	.618	.856	.749	S. SE.	SE....	S.....	4	12	12	7.3	S. 23 E	5	0	2	.....	.....
.793	8.0	.848	.817	S.....	S.....	NE...	35	25	4	19.0	S. 2 E..	6	10	3	.....	.....
.735	.848	.783	.789	NE...	NW ..	Calm..	25	2	0	8.3	N. 40 E.	0	0	0	.....	.16
.776	.618	.740	.711	NE ...	NE...	S.....	2	25	2	8.7	N. 49 E	0	1	0	.....	.....
.880	.712	.786	.793	S.....	NE...	Calm..	2	2	0	0.7	S. 73 E	6	7	2	.....	.....
.882	.768	.772	.807	S.....	NE...	S.....	2	12	2	3.3	N. 62 E.	7	8	0	.....	.....
.886	.810	.893	.863	S.....	N.....	Calm..	2	2	0	0.0	Calm...	0	0	0	.....	.....
.895	.697	.804	.799	W. NW	W	S.....	2	4	2	2.0	S. 77 W.	0	0	0	.....	.....
.846	.784	.724	.785	SE....	W	S.....	2	2	2	1.0	S. 9 W .	0	1	4	.....	.....
.751	.826	.764	.786	S.....	N.....	S.....	2	4	4	0.7	South..	0	5	5	.....	.....
.761	.792	.744	.766	S.....	W	S.....	2	2	2	1.7	S. 23 W.	0	6	10	.....	.....
.906	.711	.727	.781	S.....	E. NE.	NE...	4	2	2	1.3	S. 63 E	6	7	10	.....	.....
.804	.771	.807	.794	NE...	NE...	NE...	4	12	2	6.0	N. 45 E.	10	4	0	.....	.02
.846	.693	.734	.758	NW ..	NW ..	S.....	2	2	4	1.0	S. 66 W.	0	6	0	.....	.....
.860	.718	.854	.811	S. SW.	SW...	S.....	25	12	12	8.0	S. 23 W.	10	7	0	.....	.....
.843	.704	.836	.794	N. NW.	NW ..	S.....	12	12	2	7.3	N. 37 W.	3	6	0	.....	.49
.843	.613	.833	.763	Calm..	N. NE	SE....	0	2	2	0 7	N. 79 E	0	2	1	.....	.....
.769	.689	.848	.769	S.....	N.....	S.....	4	2	2	1.3	South.	6	8	2	.....	.....
.822	.721	.813	.785	.....	.....	.....	....	....	....	0.6	S. 1 W	4.0	4.5	2.5	.....	2.65
.783	.810	.848	.814	S.....	S.....	S.....	4	12	2	6.0	South..	5	6	3	.....	.....
.838	.768	.796	.801	N.....	N.....	N.....	2	12	12	8.7	North..	3	2	0	.....	.15
.836	.672	.793	.767	N.....	N.....	S.....	4	2	4	0.7	North..	4	0	0	.....	.....
.780	.657	.804	.747	S.....	W. NW	S.....	4	4	2	2.0	S. 8 W .	0	1	0	.....	.....
.841	.623	.854	.773	S.....	NW ..	S.....	4	2	2	1.7	S. 16 W.	0	0	0	.....	.....
.796	.711	.815	.774	W	NW ..	S.....	2	2	2	1.3	S. 80 W.	0	1	4	.....	.....
.850	1.000	.720	.857	W	N.....	S.....	2	2	2	0.7	West ..	5	5	0	.....	.....
.804	.618	.812	.745	SE....	E. NE.	SE....	2	2	2	1.7	S. 67 E .	0	5	4	.....	.....
.796	.779	.774	.783	W	N.....	S.....	2	2	2	0.7	W st .	0	2	5	.....	.....
.850	.768	.539	.719	NE...	NW ..	N.....	4	2	25	9.7	N. 3 E..	10	2	0	.....	.10
.858	.644	.708	.737	N.....	N.....	Calm..	2	4	0	2.0	North..	0	3	0	.....	.....
.685	.623	.779	.696	S.....	NW ..	S.....	2	2	2	1.0	S. 28 W.	0	0	0	.....	.....
.771	.774	.852	.799	S.....	W	N.....	4	2	4	0.7	West ..	10	10	7	.....	.....
.793	.716	.793	.767	NE...	N.....	Calm..	4	2	0	1.7	N. 34 E.	0	2	0	.....	.10
.836	.677	.751	.755	NE...	NE...	NE...	4	12	4	6.7	N. 45 E	0	0	0	.....	.....
.751	.644	.854	.750	NE...	NW ..	S. SE..	25	4	2	8.0	N. 39 E	4	5	6	.....	.....
.783	.708	.708	.733	SW...	SW...	S.....	2	2	2	1.7	S. 31 W.	0	3	0	.....	.....
.693	.560	.734	.662	SW...	SW...	SW...	4	35	12	17.0	S. 45 W.	4	5	5	.....	.....
.708	.727	.852	.762	W	W. NW	S.....	2	2	2	1.3	S. 72 W.	5	2	10	.....	.32
.848	.758	.793	.800	NE...	NE...	S.....	2	2	2	1.0	N. 75 E	7	3	0	.....	.....
.825	.716	.796	.779	N	N.....	Calm..	2	12	0	4.7	North..	8	6	2	.....	.....
.880	.810	.799	.830	E. NE	N.....	S.....	2	2	2	0.7	N. 23 E	4	2	0	.....	.....
.884	.653	.774	.770	S. SE.	NW ..	S.....	12	2	4	4.7	S. 14 E	6	6	3	.....	.....
.854	.634	.843	.777	N.....	N. NE.	W	4	4	4	2.0	S. 40 W.	10	0	0	.....	.08
.894	.802	.841	.842	SE...	NE...	Calm..	4	4	0	1.9	East ...	0	0	0	.....	.....
.828	.768	.812	.803	SE....	NE...	S.....	12	12	2	6.0	S. 83 E.	6	7	0	.....	.....
.848	.640	.865	.784	S.....	S.....	S.....	4	25	2	10.3	South..	4	6	4	.....	.....
.727	.697	.810	.745	SW...	W	NW ..	12	2	12	6.3	West...	10	7	0	.....	.....
.735	.629	.776	.713	E	W	NW ..	2	2	35	11.7	N. 45 W.	3	8	4	.....	.....
.692	.582	.692	.655	NW ..	W. NW	SE....	12	4	4	2.7	N. 49 W.	2	0	0	.....	.....
.733	.570	.780	.694	S.....	S.....	Calm..	12	12	0	8.0	South..	6	10	10	.....	.....
.800	.701	.786	.762	.....	.....	.....	....	....	....	0.4	S. 83 W.	3.7	3.5	2.2	.....	.75

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Sept. 1	29.191	29.258	29.324	29.258	62	60	57	64	63	61	62.7	67	61	.529	.478	.412	.473
2	29.354	29.326	29.328	29.336	56	62	59	60	67	62	63.0	68	57	.396	.489	.460	.448
3	29.311	29.265	29.298	29.291	57	70	65	60	76	69	68.3	76	57	.426	.652	.564	.547
4	29.383	29.345	29.308	29.345	59	65	64	61	70	68	66.3	72	61	.473	.559	.543	.525
5	29.291	29.225	29.165	29.227	62	72	70	65	77	75	72.3	78	63	.516	.718	.666	.633
6	29.195	29.295	29.433	29.308	69	65	54	73	70	63	68.7	80	63	.655	.550	.298	.501
7	29.561	29.588	29.591	29.547	55	62	58	60	69	62	63.7	72	59	.367	.462	.429	.419
8	29.564	29.491	29.428	29.494	53	65	67	56	70	70	65.3	71	54	.363	.550	.629	.514
9	29.378	29.140	29.288	29.269	64	72	70	67	82	73	74.0	82	63	.556	.650	.643	.616
10	29.441	29.458	29.446	29.448	57	56	53	59	61	58	59.3	75	58	.439	.393	.336	.389
11	29.507	29.396	29.344	29.416	45	63	55	48	67	61	58.7	68	46	.260	.522	.354	.379
12	29.352	29.306	29.245	29.301	51	67	61	54	73	69	65.3	73	52	.335	.581	.430	.449
13	29.218	29.128	29.285	29.210	60	69	62	76	80	65	73.7	81	63	.305	.480	.516	.434
14	29.476	29.498	29.496	29.490	56	58	53	59	63	57	59.7	67	57	.409	.416	.350	.392
15	29.476	29.423	29.395	29.431	57	71	71	59	79	78	72 0	81	52	.439	.651	.664	.585
16	29.460	29.481	29.452	29.464	70	75	71	73	79	75	75.7	80	71	.693	.814	.704	.737
17	29.482	29.554	29.527	29.521	72	77	73	74	83	79	78.3	82	72	.757	.860	.730	.782
18	29.565	29.522	29.502	29.530	70	77	73	73	82	76	77.0	82	73	.693	.860	.771	.775
19	29.530	29.485	29.422	29.479	67	72	73	69	75	76	73.3	77	69	.635	.744	.771	.717
20	29.378	29.347	29.551	29.425	71	75	58	74	79	63	72.0	81	63	.718	.814	.416	.649
21	29.584	29.553	29.551	29.563	64	59	55	67	65	60	64.0	70	57	.556	.420	.367	.448
22	29.526	29.476	29.496	29.499	53	71	63	55	75	67	65.7	72	49	.376	.704	.529	.536
23	29.673	29.706	29.686	29.688	59	58	53	62	63	56	60.3	70	56	.460	.416	.363	.413
24	29.664	29.516	29.638	29.606	50	68	63	53	73	67	64.3	73	50	.321	.618	.529	.489
25	29.338	29.431	29.514	29.428	64	63	53	66	70	57	64.3	70	57	.569	.482	.350	.467
26	29.577	29.529	29.480	29.529	51	54	49	54	58	52	55.7	61	52	.335	.365	.308	.336
27	29.458	29.387	29.362	29.402	41	56	50	42	61	53	52.0	62	40	.244	.383	.321	.316
28	29.332	29.264	29.206	29.267	48	62	60	50	69	66	61.7	70	48	.309	.462	.438	.403
29	29.224	29.231	29.344	29.266	57	58	51	61	63	54	59.3	67	54	.412	.416	.335	.388
30	29.507	29.418	29.520	29.482	45	47	43	48	52	46	48.7	60	46	.260	.257	.228	.248
Means....	29.433	29.401	29.421	29.418	58.2	65.0	60.2	61.4	70.4	64.6	65.5	82	40	.460	.558	.483	.500
Oct. 1	29.483	29.325	29.187	29.332	37	55	51	39	63	57	53.0	65	37	.194	.327	.295	.272
2	29.101	29.055	29.141	29.099	51	63	55	57	70	65	64.0	71	55	.295	.482	.300	.359
3	29.307	29.282	29.300	29.296	54	52	50	56	55	53	54.7	66	53	.391	.349	.321	.354
4	29.340	29.284	29.154	29.259	42	56	53	45	60	56	53.7	61	44	.228	.396	.363	.329
5	29.081	29.284	29.495	29.287	55	53	50	57	56	53	55.3	58	53	.407	.363	.321	.364
6	29.580	29.720	29.720	29.673	47	47	45	51	53	47	50.3	55	47	.270	.244	.273	.262
7	29.823	29.790	29.748	29.787	39	47	42	41	52	45	46.0	54	39	.212	.257	.228	.232
8	29.686	29.454	29.542	29.561	38	54	52	40	60	55	51.7	62	38	.203	.338	.349	.297
9	29.225	29.083	29.076	29.128	49	52	53	53	55	56	54.7	58	52	.295	.349	.363	.336
10	28.863	28.818	28.888	28.856	52	53	49	55	57	51	54.3	57	51	.349	.350	.321	.340
11	28.911	28.979	29.046	28.979	48	49	51	49	51	53	51.0	54	48	.322	.321	.348	.330
12	29.109	29.220	29.272	29.200	51	51	52	53	53	53	53.0	54	52	.348	.348	.375	.357
13	29.422	29.424	29.412	29.419	51	55	51	53	57	53	54.3	57	52	.348	.407	.348	.368
14	29.505	29.407	29.387	29.433	45	59	51	47	61	54	54.0	61	46	.273	.473	.335	.360
15	29.375	29.379	29.414	29.389	50	60	52	53	63	55	57.0	64	52	.321	.478	.349	.383
16	29.545	29.488	29.466	29.500	47	65	61	49	71	66	62.0	73	48	.297	.537	.470	.435
17	29.436	29.308	29.293	29.346	57	67	63	60	77	70	69.0	77	59	.426	.527	.488	.478
18	29.328	29.321	29.295	29.315	60	65	63	65	72	68	68.3	72	65	.451	.594	.509	.485
19	29.396	29.380	29.405	29.394	60	69	62	64	80	68	70.7	81	64	.465	.561	.478	.501
20	29.506	29.451	29.433	29.463	54	65	60	57	72	65	64.7	74	57	.378	.594	.451	.474
21	29.442	29.325	29.345	29.371	53	64	62	57	75	66	66.0	75	57	.350	.449	.508	.436
22	29.509	29.537	29.620	29.555	51	50	46	53	54	51	52.7	69	51	.348	.308	.345	.333
23	29.763	29.795	29.790	29.783	42	47	40	46	53	43	47.3	61	43	.215	.244	.308	.255
24	29.806	29.790	29.748	29.781	32	49	43	34	54	47	45.0	57	34	.155	.269	.225	.216
25	29.706	29.680	29.660	29.682	35	50	45	37	55	49	47.0	58	34	.178	.295	.247	.240
26	29.656	29.635	29.635	29.642	37	54	48	39	58	52	49.7	59	39	.194	.363	.282	.280
27	29.643	29.602	29.580	29.608	41	53	47	43	57	50	50.0	58	43	.231	.350	.283	.288
28	29.538	29.437	29.390	29.455	47	50	49	49	52	50	50.3	53	47	.297	.394	.335	.342
29	29.303	29.252	29.275	29.277	52	53	53	53	55	55	54.3	56	50	.375	.376	.376	.376
30	29.298	29.197	29.283	29.259	45	51	34	46	53	35	44.7	56	35	.286	.349	.193	.276
31	29.366	29.436	29.473	29.425	57	45	44	58	46	45	49.7	52	34	.432	.286	.275	.331
Means....	29.421	29.391	29.402	29.405	47.7	54.9	50.9	50.3	59.7	54.4	54.8	81	34	.311	.381	.336	.343

the northern and northwestern lakes at Cleveland, Ohio.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.888	.831	.769	.829	N.....	N.....	N.....	12	4	12	9.3	North..	10	8	9	.....	.15
.765	.740	.828	.778	S.....	N.....	S.....	2	2	4	1.3	South..	7	2	0	.....	.....
.822	.727	.796	.782	SE....	NW..	N.....	2	2	12	4.0	North..	0	7	10	.....	.....
.882	.751	.793	.809	S.....	N.....	Calm..	2	4	0	0.7	North..	0	8	4	.....	.02
.836	.774	.768	.793	S.....	N.....	S.....	2	4	2	....	.....	0	6	0	.....	.....
.707	.751	.519	.692	S.....	NE...	NE...	4	12	25	11.7	N. 50 E.	6	8	4	.....	.....
.708	.653	.772	.711	NE...	N.....	Calm..	4	2	0	1.7	N. 29 E.	0	0	0	.....	.....
.809	.751	.848	.803	S.SE..	N.....	E. NE.	4	12	4	3.7	N. 2 E..	0	0	0	.....	.....
.841	.595	.854	.763	S.SE..	SW...	W....	12	4	12	5.7	S. 37 W.	6	7	10	.....	.....
.878	.713	.698	.763	N.....	W.NW	S.....	12	4	2	3.3	N. 2 W.	10	4	3	.....	.01
.777	.790	.659	.742	S.SE..	SE....	S.....	4	4	2	2.0	S. 29 E.	0	0	0	.....	.....
.802	.716	.607	.708	S.....	S.....	S.....	2	2	12	5.3	South..	0	6	5	.....	.....
.340	.387	.836	.521	S.....	W....	N.....	12	4	4	3.0	S. 27 W.	7	10	10	.....	.....
.819	.723	.750	.764	NE...	NE...	NE...	2	12	12	8.7	N. 45 E.	0	5	6	.....	.26
.878	.657	.693	.743	S.....	NE...	S.SE..	2	12	12	4.7	S. 71 E.	7	4	10	.....	.....
.854	.822	.812	.829	S.....	S.....	S.....	4	12	2	6.0	South..	8	10	0	.....	.10
.903	.787	.738	.809	S.....	N.....	S.....	2	2	2	0.7	South..	0	1	0	.....	.89
.854	.787	.860	.834	S.....	N.....	W....	4	4	2	0.7	West...	2	4	4	.....	.....
.896	.858	.860	.871	SE....	N.....	S.....	2	4	4	0.7	S. 45 E.	10	3	0	.....	.....
.856	.822	.723	.800	S.....	N.....	NE...	12	12	12	4.0	N. 45 E.	0	8	0	.....	.....
.841	.680	.708	.743	SE....	N.....	S.....	2	2	12	4.0	S. 7 E..	10	7	0	.....	.....
.869	.812	.790	.824	SW...	W.NW	S.....	12	4	2	4.3	S. 40 W.	0	0	3	.....	.....
.828	.723	.809	.787	NW...	N. NE.	E.....	4	4	2	1.3	N. 10 W	5	0	0	.....	.....
.798	.761	.790	.783	SE....	SW...	S.....	2	4	2	2.3	S. 11 W	0	0	0	.....	.....
.891	.658	.752	.767	W....	NE...	N.....	12	12	25	11.3	N. 6 W.	0	4	6	.....	.....
.802	.756	.794	.784	NE...	N.....	S.....	2	2	2	0.7	N. 45 E.	10	5	0	.....	.....
.914	.713	.798	.808	S.....	NE...	S.....	2	2	2	1.0	S. 28 E.	0	0	0	.....	.....
.856	.653	.685	.731	S.....	NW...	SE....	12	2	2	4.0	South..	0	0	0	.....	.....
.769	.723	.802	.765	S.....	NE...	NE...	2	45	35	26.0	N. 46 E.	0	10	10	.....	.....
.777	.660	.767	.735	NE...	NW..	S.....	12	2	2	3.7	N. 44 E.	10	3	0	.....	.....
.825	.726	.762	.771	.....	.....	.....	....	....	....	1.7	N. 47 E.	3.6	4.3	3.1	.....	1.43
.816	.568	.634	.673	S.....	S.....	S.....	2	4	4	3.3	South..	0	0	0	.....	.....
.634	.658	.487	.593	S.SW.	S.....	NE...	4	4	2	1.0	S. 25 E.	8	10	10	.....	.....
.872	.805	.798	.825	N. NE	N.....	S.....	2	12	2	3.7	N. 4 E..	10	10	3	.....	.07
.762	.765	.809	.779	S.....	S.....	N.....	2	12	2	4.0	South..	0	0	10	.....	.04
.874	.809	.798	.827	N.....	NW..	N.....	25	25	25	23.3	N. 14 W	10	8	5	.....	.86
.722	.606	.847	.725	NE...	NE...	NE...	12	2	2	5.3	N. 45 E.	2	0	6	.....	.....
.824	.660	.762	.749	S.....	N.....	S.....	2	2	2	0.7	South..	4	6	0	.....	.....
.820	.653	.805	.759	S.....	S.....	S.....	12	2	2	5.6	South..	0	0	5	.....	.....
.733	.805	.809	.782	S.....	S.....	S c....	12	25	25	20.7	South..	10	10	10	.....	.....
.805	.752	.859	.805	SW...	SW..	SW..	25	12	12	16.3	S. 45 W	10	10	10	.....	.36
.926	.859	.864	.883	SW...	W....	W....	2	2	12	5.3	S. 85 W	10	10	10	.....	.36
.864	.864	.932	.867	NW...	NW..	NW..	12	2	25	13.0	N. 55 W	10	7	10	.....	.23
.864	.874	.864	.867	NW...	W.NW	SW..	4	12	2	5.7	N. 69 W	5	3	0	.....	.49
.847	.882	.802	.844	S.....	W.NW	S.....	2	2	2	1.3	S. 26 W	0	3	0	.....	.....
.798	.831	.805	.811	SW...	W....	S.....	4	4	2	2.7	S. 53 W	0	0	0	.....	.....
.853	.708	.735	.765	S.....	S.....	S.....	2	4	2	2.7	South..	0	0	0	.....	.....
.822	.569	.658	.683	SW...	SW..	SW..	2	4	4	3.3	S. 45 W	0	6	10	.....	.....
.731	.668	.743	.714	S. SW.	NW..	S.....	2	2	2	1.0	S. 44 W	0	0	0	.....	.....
.780	.548	.695	.674	S.....	N.....	S.....	2	2	2	0.7	South..	4	0	0	.....	.....
.812	.668	.731	.737	S.SE..	NE...	S.....	2	2	2	1.0	S. 44 E.	6	0	0	.....	.....
.762	.518	.786	.689	SE....	S. SW	S.....	2	12	2	5.0	S. 13 W	0	5	10	.....	.....
.864	.738	.653	.752	N.....	N.....	N.....	12	4	25	13.7	North..	10	9	6	.....	.24
.691	.606	.750	.682	N.....	NW..	SE....	12	2	2	4.0	North..	4	2	0	.....	.....
.792	.674	.698	.721	S.....	N.....	SE....	2	2	2	0.7	S. 45 E.	0	0	0	.....	.....
.807	.681	.710	.733	SE....	N. NE.	SE....	2	2	2	1.3	S. 74 E.	2	8	0	.....	.....
.816	.756	.727	.766	SE....	W....	SE....	2	2	2	1.0	S. 16 E.	0	0	0	.....	.....
.833	.752	.786	.790	SE....	NE...	S.....	2	12	2	3.7	N. 62 E.	0	0	0	.....	.07
.853	.861	.927	.880	SE....	SE....	NE...	2	4	4	2.7	S. 80 E.	10	10	10	.....	.54
.932	.869	.869	.890	NE...	N.....	NE...	25	4	2	10.3	N. 50 E.	10	10	3	.....	.....
.921	.864	.898	.894	SE....	W....	SW..	2	12	12	7.3	S. 65 W	7	10	10	.....	.32
.937	.921	.920	.926	SW...	SW..	W.NW	4	12	4	5.3	S. 46 W	8	10	10	.....	.....
.818	.735	.679	.777	... .	.....	.....	....	....	....	0.4	S. 86 W	3.6	3.8	4.5	.....	3.58

Reductions of the monthly meteorological register of the survey of

Date.		Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
						Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
		7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.						°	°	°	°	°	°	°	°	°				
Nov.	1	29.411	29.180	29.086	29.229	41	52	49	42	59	55	52.0	60	38	.244	.296	.289	.270
	2	29.071	29.088	29.146	29.102	51	56	48	55	61	52	56.0	62	52	.321	.363	.282	.322
	3	28.954	28.771	28.796	28.840	48	61	59	51	63	61	58.3	64	47	.296	.510	.473	.426
	4	29.241	29.588	29.578	29.402	40	41	39	42	43	42	42.3	61	39	.221	.231	.199	.217
	5	29.734	29.623	29.616	29.658	30	40	35	33	48	39	40.0	48	32	.132	.143	.152	.142
	6	29.694	29.626	29.516	29.612	33	45	37	36	50	40	42.0	50	37	.149	.234	.181	.188
	7	29.364	29.195	29.163	29.241	38	49	45	41	58	51	50.0	58	39	.190	.229	.230	.216
	8	29.143	29.076	28.973	29.064	44	60	58	49	68	64	60.3	69	47	.223	.411	.403	.346
	9	29.117	29.169	29.267	29.184	51	51	49	55	60	55	56.7	65	53	.321	.255	.269	.282
	10	29.353	29.302	29.380	29.345	43	48	43	47	57	48	50.7	61	46	.225	.217	.212	.218
	11	29.398	29.358	29.428	29.395	37	34	37	40	39	38	39.0	48	36	.181	.131	.207	.173
	12	29.462	29.452	29.447	29.454	35	35	35	38	38	38	38.0	38	36	.165	.165	.165	.165
	13	29.342	29.301	29.236	29.293	29	43	35	32	47	37	38.7	47	31	.126	.225	.178	.176
	14	29.037	29.129	29.333	29.166	42	43	40	45	47	43	45.0	48	35	.228	.225	.226	.226
	15	29.604	29.543	29.291	29.479	32	40	35	35	44	40	39.7	45	35	.142	.195	.139	.159
	16	29.244	29.294	29.442	29.327	41	37	35	45	40	35	40.0	47	38	.205	.181	.234	.197
	17	29.300	29.286	29.249	29.278	32	39	39	35	41	42	39.3	43	34	.142	.212	.199	.184
	18	29.390	29.274	29.440	29.368	32	32	30	34	35	32	33.7	43	32	.155	.142	.144	.147
	19	29.578	29.563	29.506	29.549	28	35	27	30	40	29	33.0	42	29	.130	.139	.124	.131
	20	29.435	29.373	29.415	29.408	32	44	39	34	51	43	42.7	51	27	.155	.196	.186	.179
	21	29.499	29.417	29.407	29.441	31	48	44	33	53	47	44.3	53	33	.151	.269	.249	.223
	22	29.406	29.352	29.352	29.370	41	49	47	44	54	50	49.3	54	43	.218	.282	.283	.261
	23	29.435	29.392	29.410	29.412	54	58	50	56	62	53	57.0	63	45	.391	.429	.321	.380
	24	29.323	29.247	29.300	29.290	50	58	56	52	65	59	58.7	65	49	.334	.389	.449	.377
	25	29.225	29.113	29.114	29.151	52	55	52	55	58	54	55.7	61	54	.349	.393	.362	.368
	26	29.413	29.466	29.543	29.474	40	41	39	41	43	41	41.7	51	41	.235	.231	.212	.226
	27	29.214	29.378	29.323	29.305	39	42	42	46	44	43	44.3	54	40	.147	.241	.254	.214
	28	29.343	29.344	29.334	29.340	41	43	42	42	44	43	43.0	51	42	.244	.264	.254	.254
	29	28.952	28.829	28.960	28.914	41	44	31	42	45	32	39.7	45	32	.244	.275	.162	.227
	30	29.251	29.436	29.546	29.411	19	15	13	20	16	14	16.7	32	14	.092	.074	.067	.078
Means....		29.331	29.299	29.320	29.317	38.9	44.6	41.0	41.7	49.1	44.0	44.9	69	14	.212	.252	.233	.232
Dec.	1	29.602	29.441	29.451	29.498	9	20	21	10	21	22	17.7	22	7	.054	.096	.101	.084
	2	29.366	29.380	29.480	29.409	26	32	30	27	33	31	30.3	36	20	.129	.168	.155	.151
	3	29.531	29.331	29.236	29.366	24	31	32	25	32	33	30.0	35	23	.117	.162	.168	.149
	4	29.270	29.190	29.105	29.188	24	24	21	27	26	22	25.0	33	22	.095	.106	.101	.101
	5	29.153	29.234	29.290	29.226	21	28	27	22	29	28	26.3	30	20	.101	.142	.136	.126
	6	28.895	28.698	29.012	28.868	34	43	35	35	45	36	38.7	48	28	.183	.251	.191	.208
	7	29.328	29.338	29.486	29.384	24	24	19	25	27	20	24.0	36	20	.117	.095	.092	.101
	8	29.577	29.536	29.521	29.545	19	23	21	20	24	22	22.0	25	16	.092	.112	.101	.102
	9	29.624	29.580	29.242	29.449	22	27	29	23	29	31	27.7	32	20	.107	.124	.137	.123
	10	29.228	29.213	29.242	29.228	34	32	30	35	35	31	33.7	36	31	.183	.142	.155	.160
	11	29.278	29.212	29.228	29.239	30	30	26	31	31	27	29.7	32	27	.155	.153	.129	.146
	12	29.013	29.067	29.285	29.122	16	12	11	17	13	12	14.0	27	10	.078	.063	.061	.067
	13	29.457	29.671	29.468	29.532	12	20	5	18	22	6	13.7	22	6	.063	.085	.043	.064
	14	29.363	29.274	29.300	29.312	4	18	16	5	19	17	13.7	20	− 1	.041	.087	.078	.068
	15	29.291	29.289	29.291	29.290	16	22	16	17	23	17	19.0	23	16	.078	.107	.078	.088
	16	29.295	29.233	29.172	29.233	13	23	20	14	25	21	20.0	26	11	.067	.100	.096	.088
	17	28.921	29.015	29.185	29.040	24	28	31	25	30	32	29.0	33	19	.117	.130	.162	.136
	18	29.368	29.468	29.623	29.486	29	28	25	36	29	26	30.3	34	26	.080	.142	.123	.115
	19	29.801	29.695	29.515	29.670	17	22	19	18	25	20	21.0	26	17	.083	.084	.092	.086
	20	29.318	29.432	29.612	29.454	34	33	32	35	35	33	34.3	37	20	.183	.162	.168	.171
	21	29.660	29.417	29.146	29.408	28	33	37	50	35	39	34.7	39	30	.130	.162	.194	.162
	22	28.839	28.989	29.115	28.981	49	36	32	50	38	34	40.7	50	34	.335	.186	.155	.225
	23	29.448	29.631	29.651	29.577	27	29	26	28	31	27	28.7	40	27	.136	.137	.129	.134
	24	29.343	29.287	29.373	29.334	29	37	35	35	39	36	35.0	40	25	.149	.194	.191	.178
	25	29.204	29.006	28.849	29.020	43	47	54	45	50	55	50.0	56	35	.251	.283	.404	.313
	26	29.364	29.397	29.252	29.338	33	40	38	34	42	48	41.3	53	34	.175	.221	.099	.165
	27	28.965	28.806	29.251	29.007	54	60	57	55	61	59	51.7	61	39	.404	.505	.194	.368
	28	29.404	29.445	29.483	29.444	32	33	30	34	35	32	33.7	43	32	.155	.162	.144	.154
	29	29.655	29.670	29.758	29.694	24	26	24	25	28	25	26.0	28	25	.117	.117	.117	.117
	30	29.821	29.865	29.868	29.851	19	21	17	20	22	18	20.0	25	18	.092	.101	.083	.092
	31	29.701	29.452	29.228	29.460	16	26	27	17	29	28	25.3	30	16	.078	.106	.136	.107
Means....		29.357	29.331	29.346	29.345	25.3	29.3	26.5	26.7	31.1	28.0	28.6	61	− 1	.134	.151	.136	.140

the northern and northwestern lakes at Cleveland, Ohio.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.914	.592	.620	.709	S.....	S.....	S.....	2	25	35	20.7	South..	2	4	0	.....	.....
.743	.713	.727	.728	SW..	W.....	S.....	12	2	2	5.0	S. 45 W.	0	4	0	.....	.....
.790	.886	.882	.853	S.....	S.....	S.....	12	12	45	23.0	South..	7	10	10	.....	.....
.829	.833	.744	.802	SW..	W.....	NW..	12	25	35	20.3	N. 74 W.	10	7	8	.....	.75
.703	.426	.636	.588	SW..	SW..	S.....	4	12	2	6.0	S. 40 W.	1	6	0	.....	.27
.705	.646	.732	.694	S. SW.	W.NW	S.....	2	2	2	1.3	S. 41 W.	7	6	3	.....	.....
.738	.475	.590	.601	S.....	S.....	S.....	4	2	2	2.7	South..	3	5	6	.....	.....
.638	.601	.675	.638	S.....	S.....	S.....	12	25	25	20.7	South..	0	8	8	.....	.....
.743	.493	.620	.619	SW..	SW...	S.....	2	2	2	1.7	S. 34 W.	10	3	3	.....	.33
.698	.465	.631	.598	SE....	SW...	SE....	2	2	2	1.7	S. 16 E.	10	6	0	.....	.....
.732	.547	.905	.728	S. SW.	W.....	W.NW	2	4	35	13.0	N. 73 W.	10	8	10	.....	.02
.719	.719	.719	.719	NW..	NW..	NW..	25	25	25	25.0	N. 45 W.	10	10	10	.....	.14
.694	.698	.807	.733	SE....	W.....	S.....	4	4	2	1.7	S. 15 W.	9	0	3	.....	.....
.762	.698	.750	.737	W.....	W.NW	N.....	4	25	35	17.3	N. 31 W.	0	7	10	.....	.....
.698	.677	.557	.644	N.....	SW...	S.....	2	2	2	0.7	S. 45 W.	6	2	3	.....	.....
.684	.732	1.000	.805	NW..	NW..	NW..	12	12	25	16.3	N. 45 W.	5	10	7	.....	.....
.698	.824	.744	.755	SW..	W.NW	NW..	2	4	25	8.7	N. 50 W.	10	10	10	.....	.....
.792	.698	.794	.761	N.....	NW..	NW..	4	2	12	5.7	N. 35 W.	9	6	7	.....	.....
.782	.557	.775	.705	NW..	NW..	SE....	2	2	2	0.7	N. 45 W.	5	0	0	.....	.....
.792	.525	.669	.662	S.....	SW...	S.....	4	2	2	2.7	S. 10 W.	0	0	3	.....	.....
.800	.667	.772	.746	S.....	S.....	S.....	2	2	4	2.7	South..	10	0	0	.....	.....
.756	.674	.786	.739	S.....	S.....	S.....	4	2	2	2.7	South..	10	0	0	.....	.....
.872	.772	.798	.814	S.....	S.....	S.....	2	2	2	2.0	South..	0	0	0	.....	.....
.861	.631	.819	.770	S.....	S.....	S.....	2	4	2	2.7	South..	10	7	10	.....	.03
.805	.816	.867	.829	S. SE..	S. SE.	W.....	4	25	12	8.0	S. 5 W..	10	10	10	.....	.02
.912	.833	.824	.856	W.NW	W.....	S.....	4	2	2	1.0	S. 51 W.	10	10	10	.....	.22
.471	.836	.916	.741	SE....	SW...	SW...	2	2	2	1.7	S. 16 W.	10	10	10	.....	.....
.914	.918	.916	.916	NE...	NW..	S.....	2	2	2	0.3	North..	10	10	10	.....	.07
.914	.920	.896	.910	S.....	N.....	N.....	4	4	60	20.0	North..	10	10	10	.....	.09
.850	.829	.816	.832	W.NW	SW...	W.NW	35	25	35	27.7	N. 83 W.	10	10	10	.....	.78
.767	.690	.766	.741	.....	.....	.....	....	....	....	4.0	S. 83 W.	6.8	6.0	5.7	.....	2.72
.791	.855	.860	.835	S.....	S.....	S.....	2	12	12	8.7	South..	10	10	10	.....	.10
.880	.893	.893	.889	SW..	SW..	SW...	4	4	12	6.7	S. 45 W.	10	0	10	.....	.36
.872	.896	.893	.887	S.....	S. SW.	SW...	2	4	12	4.7	S. 39 W.	10	10	10	.....	.....
.644	.754	.860	.753	W.....	W.....	S.....	25	4	2	9.7	S. 86 W.	10	4	10	.....	.....
.860	.887	.883	.877	SW..	SW...	S.....	4	4	2	3.0	S. 36 W.	10	10	10	.....	.....
.896	.840	.900	.879	SW..	SW...	W.....	12	35	45	28.3	S. 67 W.	10	6	10	.....	.....
.872	.644	.850	.789	W.....	W.....	W.....	25	12	45	27.3	West...	10	7	10	.....	.07
.850	.868	.860	.859	W.....	W.....	W.....	12	12	45	23.0	West...	10	8	10	.....	.63
.864	.775	.788	.809	SW..	SW...	SW...	4	2	12	6.0	S. 45 W.	10	10	10	.....	.....
.898	.696	.893	.830	W.....	NE....	NE....	2	2	2	1.0	N. 18 E.	10	10	10	.....	.....
.893	.893	.880	.889	NE....	NE....	NE....	2	2	25	9.7	N. 45 E.	10	10	10	.....	.....
.634	.810	.804	.816	NE....	NE....	NE....	35	35	25	31.7	N. 45 E.	10	10	10	.....	.28
.810	.721	.760	.764	NE....	NE....	Calm..	2	2	0	1.3	N. 45 E.	6	0	2	.....	.74
.750	.845	.834	.810	SE....	NE....	E.....	2	2	2	1.6	East...	7	10	10	.....	.....
.834	.864	.834	.844	S.....	W.NW	S.....	2	2	2	1.3	S. 21 W.	10	10	0	.....	.....
.816	.746	.855	.806	SE....	SE....	S.....	2	4	12	5.7	S. 15 E.	10	10	10	.....	.....
.872	.782	.896	.850	W.....	W.....	W.....	2	4	2	2.7	West...	10	10	10	.....	.....
.376	.887	.876	.713	N.....	N.....	N.....	2	4	2	2.7	North..	10	10	10	.....	.....
.840	.622	.850	.771	SE....	SE....	SE....	4	2	4	3.3	S. 45 E.	6	8	10	.....	.....
.898	.797	.893	.863	S.....	W.SW	NW..	2	4	2	0.7	S. 71 W.	10	10	10	.....	.32
.782	.797	.816	.798	SE....	SE....	S.....	2	4	35	13.3	S. 6 E..	10	10	10	.....	.....
.927	.811	.792	.843	S.....	SW...	W.NW	2	25	25	14.0	S. 75 W.	10	10	10	.....	.63
.883	.788	.880	.850	W.....	W.....	E.....	25	4	2	9.0	West...	10	10	10	.....	.....
.890	.816	.900	.869	S.....	S.....	S.....	2	12	2	5.3	South..	10	0	0	.....	.....
.840	.786	.934	.853	S.....	S.....	S.....	4	35	12	17.0	South..	10	10	10	.....	.....
.895	.829	.292	.672	S.....	W.....	S.....	2	2	25	9.3	S. 4 W.	0	8	5	.....	.34
.934	.941	.816	.897	S.....	S. SW.	W.....	12	25	4	12.7	S. 21 W.	10	10	10	.....	.....
.792	.797	.794	.794	W.....	W.NW	NW..	2	2	2	2.0	N. 67 W.	10	9	0	.....	.39
.872	.768	.872	.837	NW..	NW..	NW..	4	12	4	6.7	N. 45 W.	6	6	0	.....	.....
.850	.860	.840	.850	W.....	W.....	E.....	4	2	2	1.3	West..	8	8	0	.....	.....
.834	.665	.883	.794	E.....	E.....	E.....	4	12	12	9.3	East...	5	10	10	.....	.....
.834	.804	.838	.825	.....	.....	.....	....	....	....	3.7	S. 55 W.	9.0	8.2	8.0	.....	3.26

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Jan. 1	29.563	29.577	29.600	29.580	19	22	19	20	26	21	22.3	33	19	.092	.072	.080	.081
2	29.636	29.525	29.463	29.541	14	18	14	15	19	16	13.3	33	14	.071	.087	.059	.072
3	29.508	29.429	29.393	29.443	13	22	18	14	25	20	19.7	26	13	.067	.084	.076	.076
4	29.442	29.411	29.399	29.417	21	29	28	24	32	29	28.3	33	19	.079	.126	.142	.116
5	29.099	28.883	28.841	28.944	23	32	31	25	35	32	30.7	36	23	.100	.142	.162	.135
6	29.061	29.079	29.137	29.099	27	27	25	28	29	26	27.7	36	26	.136	.124	.123	.128
7	29.325	29.278	29.245	29.283	18	20	18	19	24	19	20.7	32	18	.087	.062	.087	.078
8	29.150	29.060	29.130	29.113	16	19	16	17	21	17	18.3	32	16	.078	.080	.078	.078
9	29.100	28.974	28.854	28.976	20	26	22	21	27	23	23.7	32	16	.096	.129	.107	.111
10	28.784	28.786	29.005	28.858	18	24	17	19	26	19	21.3	32	18	.087	.106	.071	.088
11	29.030	29.147	29.293	29.157	16	21	15	17	22	16	18.3	25	15	.078	.101	.074	.084
12	29.566	29.633	29.596	29.598	10	13	10	11	16	11	12.7	31	10	.057	.044	.057	.056
13	29.238	29.030	29.035	29.101	13	16	14	14	17	15	15.3	31	9	.067	.076	.071	.072
14	29.318	29.288	29.266	29.291	13	16	10	14	18	11	14.3	27	11	.067	.067	.057	.064
15	29.362	29.431	29.488	29.427	8	11	2	9	13	3	08.3	20	3	.051	.049	.036	.045
16	29.411	29.224	29.017	29.217	12	21	21	13	23	22	19.3	26	0	.063	.090	.101	.085
17	29.077	29.223	29.416	29.239	16	15	13	18	16	15	16.3	26	13	.067	.074	.056	.066
18	29.612	29.532	29.484	29.543	5	7	7	5	9	8	07.3	18	3	.053	.037	.048	.047
19	29.403	29.258	29.168	29.276	1	12	12	1	14	14	09.7	17	0	.045	.052	.052	.050
20	29.208	29.045	28.892	29.048	8	15	15	10	19	16	15.3	21	8	.040	.040	.074	.051
21	28.810	28.754	28.832	28.799	16	21	19	17	23	20	20.0	24	14	.078	.090	.092	.087
22	29.145	29.220	29.285	29.217	18	19	18	19	21	19	19.7	27	15	.087	.080	.087	.085
23	29.343	29.442	29.502	29.429	19	22	23	20	24	24	22.7	26	18	.092	.095	.112	.100
24	29.672	29.631	29.622	29.642	23	26	22	24	28	24	25.3	30	23	.112	.117	.095	.108
25	29.497	29.124	28.789	29.137	21	25	31	22	27	32	27.0	33	22	.101	.112	.162	.125
26	28.724	28.757	28.817	28.766	26	21	20	27	22	22	23.7	35	21	.129	.101	.085	.105
27	29.020	29.083	29.303	29.135	17	15	19	17	16	20	17.7	23	16	.094	.074	.092	.087
28	29.401	29.383	29.391	29.392	16	15	13	17	16	13	15.3	23	13	.078	.074	.078	.077
29	29.380	29.449	29.520	29.443	6	9	5	6	10	6	07.3	16	4	.057	.054	.043	.051
30	29.620	29.586	29.562	29.589	2	8	8	2	11	9	07.3	15	0	.047	.028	.051	.042
31	29.369	29.295	29.110	29.258	24	31	36	25	34	40	33.0	41	7	.117	.139	.203	.153
Means....	29.287	29.243	29.241	29.257	15.4	19.3	17.5	16.4	21.4	18.8	18.9	41	3	.080	.084	.087	.084
Feb. 1	29.065	29.168	29.263	29.165	36	28	28	38	33	31	34.0	45	31	.186	.096	.119	.134
2	29.159	28.794	28.638	28.864	23	30	31	25	31	33	29.7	34	22	.100	.155	.151	.135
3	28.601	28.696	28.781	28.693	31	28	27	32	30	28	30.0	38	27	.169	.130	.136	.145
4	29.087	28.978	28.828	28.964	25	35	31	26	37	33	32.0	36	26	.123	.178	.151	.151
5	28.948	29.193	29.303	29.148	31	29	30	33	31	31	31.7	36	27	.151	.137	.155	.148
6	29.389	29.449	29.469	29.436	24	26	24	25	29	25	26.3	33	24	.117	.106	.117	.113
7	29.712	29.644	29.598	29.651	22	38	29	24	46	33	34.3	47	21	.095	.125	.114	.111
8	29.491	29.313	29.157	29.320	27	42	41	32	50	45	42.3	53	28	.090	.162	.205	.152
9	28.963	28.871	28.987	28.940	38	31	17	39	32	18	29.7	47	18	.216	.162	.083	.154
10	29.400	29.814	29.945	29.720	6	10	10	6	12	12	10.0	20	5	.057	.046	.046	.050
11	29.935	29.673	29.613	29.807	7	27	28	8	31	31	23.3	36	5	.048	.101	.119	.089
12	29.695	29.672	29.654	29.674	32	37	38	34	43	42	39.7	43	31	.155	.148	.177	.160
13	29.452	29.441	29.271	29.388	39	45	45	43	47	47	45.7	48	41	.186	.273	.273	.244
14	29.535	29.590	29.628	29.584	55	35	31	57	36	33	42.0	48	32	.407	.191	.151	.250
15	29.765	29.693	29.513	29.657	22	28	29	23	31	31	28.3	34	22	.107	.119	.137	.121
16	29.230	29.022	29.120	29.124	42	42	33	44	43	36	41.0	48	30	.241	.254	.169	.221
17	29.342	29.423	29.453	29.406	30	32	29	33	35	31	33.0	37	31	.132	.148	.137	.139
18	29.389	29.180	29.240	29.270	27	41	34	29	44	36	36.3	47	26	.124	.218	.176	.173
19	29.551	29.541	29.403	29.498	27	27	21	28	28	22	26.0	36	22	.136	.136	.101	.124
20	29.283	29.321	29.387	29.330	19	26	25	20	28	26	24.7	31	18	.092	.117	.123	.111
21	29.211	29.019	29.024	29.085	26	28	26	28	29	27	28.0	33	23	.117	.142	.129	.129
22	29.477	29.572	29.551	29.533	24	23	12	26	24	13	21.0	28	12	.106	.112	.063	.094
23	29.287	28.967	28.775	29.010	24	37	38	26	41	42	36.3	43	11	.106	.169	.177	.150
24	29.078	29.433	29.412	29.308	30	29	22	33	32	24	29.7	44	23	.139	.126	.095	.120
25	29.545	29.433	29.437	29.472	18	31	21	19	31	22	24.0	31	18	.087	.174	.101	.120
26	29.525	29.615	29.679	29.606	22	29	28	23	34	29	28.7	35	21	.107	.103	.142	.117
27	29.769	29.745	29.699	29.738	23	34	28	25	38	29	30.7	39	22	.100	.144	.142	.129
28	29.525	29.382	29.352	29.420	32	37	35	34	43	39	38.7	46	27	.155	.142	.152	.150
Means....	29.372	29.351	29.328	29.350	27.2	31.5	28.2	28.3	34.5	30.0	30.9	53	5	.137	.146	.146	.143

the northern and northwestern lakes at Buffalo, New York.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											o					
.850	.515	.712	.692	SW..	W.SW	NW...	2	4	4	2.3	N. 89 W.	10	4	10	.....	.....
.923	.845	.659	.776	W.SW	W.SW	S	2	12	4	5.3	S. 54 W.	10	10	0	.....	.....
.816	.622	.702	.747	SW...	SW...	SW...	4	4	2	3.3	S. 45 W.	6	0	0	.....	.....
.610	.694	.887	.730	SW...	SW...	E. SE.	4	4	2	2.3	S. 31 W.	10	9	10	.....	.....
.746	.698	.896	.780	NE ...	SW...	SW...	2	2	2	0.7	S. 45 W.	10	10	10	.....	.....
.863	.775	.876	.845	W	W.by S	NW...	2	4	4	3.0	N. 77 W.	10	10	10	.....	.22
.845	.483	.845	.724	SW..	NW ..	NW...	4	4	2	2.7	N. 80 W.	10	10	10	.....	.....
.834	.712	.834	.793	W.SW	N	W.NW	2	2	2	1.3	N. 60 W.	10	10	10	.....	.....
.855	.880	.864	.866	SW ...	SW...	SW...	2	2	4	2.7	S.45 W.	10	10	10	.....	.....
.845	.754	.692	.764	SW ..	W	NW...	2	2	2	1.6	West..	10	10	10	.....	.08
.834	.860	.829	.841	W	W.SW	NW...	2	2	2	1.7	N. 83 W.	10	10	1	.....	.....
.797	.492	.797	.695	NW...	NE ...	NE ...	4	2	2	1.9	North ..	4	3	10	.....	.02
.816	.834	.823	.224	NE ...	NE ...	NE ...	4	4	2	3.3	N. 45 E.	10	10	10	.....	.02
.816	.682	.797	.765	NE ...	NE ...	NE ...	2	4	2	2.7	N. 45 E.	10	10	10	.....	.....
.784	.623	.730	.712	NE ...	NW...	N	2	2	2	1.6	North ..	10	3	0	.....	.....
.810	.730	.860	.800	SE....	S. SW.	NE ...	2	12	2	4.0	S. 6 W.	10	10	10	.....	.....
.682	.829	.648	.720	NW.W	NE ...	NW...	2	2	12	4.7	N. 38 W.	10	10	10	.....	.18
1.000	.568	.777	.782	NW ..	NW...	NW...	2	4	12	6.0	N. 45 W.	7	10	10	.....	.14
1.000	.635	.635	.757	W.SW	W.SW	NW.W	2	12	4	5.7	S. 79 W.	10	0	10	.....	.....
.582	.392	.829	.601	S	NE ...	E. NE.	2	4	4	2.3	N. 71 E.	10	10	10	.....	.....
.834	.730	.850	.805	NE ...	NE ...	NE ...	4	2	2	2.7	N. 45 E.	10	10	10	.....	.56
.845	.712	.845	.801	SW...	SW...	SW...	2	12	4	6.0	S. 45 W.	10	10	10	.....	.04
.850	.738	.868	.819	SW...	SW...	SW...	2	4	2	2.7	S. 45 W.	10	10	10	.....	.02
.868	.768	.738	.791	SW...	SW...	SW...	2	2	2	1.7	S. 74 W.	10	10	10	.....	.....
.860	.761	.896	.839	NE ...	NE ...	SE. E.	2	2	2	1.7	N. 70 E.	10	10	10	.....	.....
.880	.860	.721	.820	SW...	SW...	SW...	25	35	25	28.3	S. 45 W.	10	10	10	.....	.01
1.000	.829	.850	.893	NW ..	SW...	NW...	25	45	25	22.7	N. 87 W.	10	10	0	.....	.10
.834	.829	1.000	.888	SW...	SW...	SW...	12	45	45	34.0	S. 45 W.	10	10	10	.....	.24
1.000	.791	.760	.850	W	SW...	SW...	12	35	4	16.0	S. 55 W.	1	0	0	.....	.14
1.000	.398	.784	.727	SW...	SW...	NE ...	2	4	2	1.3	S. 45 W.	10	10	0	.....	.....
.872	.712	.820	.801	SW...	SW...	SW...	4	12	12	9.3	S. 45 W.	10	10	10	.....	.....
.840	.701	.801	.781	.....	.....	.....	....	....	....	4.5	S. 64 W.	9.3	8.5	7.8	.....	1.77
.811	.510	.685	.669	W.SW	W.NW	NW...	4	4	2	3.0	N. 81 W.	10	10	6	.....	.....
.746	.893	.800	.813	NE ...	NE ...	NE ...	4	4	4	4.0	N. 45 E.	10	10	10	.....	.....
.896	.782	.883	.854	SW...	SW...	SW...	12	35	25	24.0	S. 45 W.	10	10	10	.....	.22
.876	.807	.800	.828	W.SW.	E. NE	NE ...	4	4	4	1.3	N. 45 E.	10	10	10	.....	.....
.800	.788	.893	.827	W.SW.	W.NW	W. SW	2	4	4	3.0	S 85 W.	10	10	10	.....	.30
.872	.665	.872	.803	SW...	SW...	SW...	4	12	25	13.7	S. 45 W.	10	10	6	.....	.06
.738	.400	.606	.581	SW. S.	S. SW.	NE ...	2	2	2	0.7	S. 12 W.	1	1	0	.....	.....
.496	.459	.684	.543	S	S	S	2	2	2	2.0	South ..	3	9	10	.....	.....
.907	.896	.840	.881	SW...	N. NW	N.NW.	2	4	25	8.7	N. 28 W.	10	10	10	.....	....
1.000	.610	.610	.740	NW...	NW ..	NW...	12	2	12	8.7	N. 45 W.	10	1	1	.....	.18
.777	.582	.685	.681	SW...	SW ..	SW...	4	12	25	13.7	S. 45 W	10	5	10	.....	.....
.792	.511	.661	.655	S	S. by W	SW...	4	4	12	6.3	S. 29 W.	10	7	10	.....	.....
.669	.847	.847	.788	SW...	SW...	SW...	4	12	25	13.7	S. 45 W.	10	10	10	.....	.....
.874	.900	.800	.858	NW...	NE ...	NE ...	2	2	4	2.0	N. 28 E.	10	10	10	.....	.....
.864	.685	.788	.779	NE ...	NE ...	NE ...	2	4	4	3.3	N. 45 E.	10	9	10	.....	.....
.836	.916	.705	.819	SW...	SW...	SW...	12	35	35	27.0	S. 45 W.	10	3	10	.....	.02
.703	.698	.788	.730	SW...	SW...	SW...	25	25	2	17.3	S. 45 W.	10	1	1	.....	.00
.775	.756	.802	.778	SW...	SW...	NW ..	2	2	2	1.7	S. 74 W.	10	10	10	.....	.....
.883	.883	.860	.875	NE ...	NE ...	NE ...	2	2	12	5.3	N. 45 E.	10	10	10	.....	.....
.850	.768	.876	.831	NE ...	NE ...	NE ...	25	2	2	9.7	N. 45 E.	10	10	10	.....	.12
.768	.887	.880	.845	E. by S.	NE ...	NW ..	2	2	12	3.7	N. 27 W.	10	10	10	.....	.....
.754	.868	.811	.811	E	NW...	NE ...	4	4	2	1.7	N. 32 E.	10	7	0	.....	.22
.754	.653	.661	.689	E. SE .	S	W. SW	2	12	12	6.7	S. 28 W.	10	10	10	.....	.02
.703	.694	.738	.712	NW...	NW...	NW...	2	4	4	3.3	N. 45 W.	9	10	8	.....	.16
.845	1.000	.860	.902	NE ...	NE ...	NE ...	2	4	4	3.3	N. 45 E.	10	3	1	.....	.....
.864	.524	.887	.758	SW...	SW...	SW ..	2	4	12	6.0	S. 45 W.	10	10	0	.....	.....
.746	.628	.887	.754	SW...	SW...	NE ...	2	4	2	1.3	S. 45 W.	0	1	0	.....	.....
.792	.511	.636	.646	S	S	S	2	2	2	2.0	South ..	10	10	4	.....	.....
.800	.718	.780	.766	.....	.....	.....	....	....	....	3.8	S. 58 W.	8.2	7.0	6.4	.....	1.36

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
March 1	29.203	28.924	28.747	28.958	37	47	47	39	50	49	46.0	55	37	.194	.283	.297	.258
2	28.820	29.097	29.348	29.088	35	25	16	36	26	18	26.7	50	18	.191	.121	.067	.127
3	29.486	29.390	29.197	29.358	13	18	17	15	21	18	18.0	22	14	.056	.065	.083	.068
4	29.124	29.281	29.417	29.274	22	25	25	23	28	26	25.7	30	17	.107	.100	.123	.110
5	29.588	29.651	29.713	29.651	23	25	19	24	28	20	24.0	32	20	.112	.100	.095	.102
6	29.788	29.637	29.514	29.646	17	25	24	18	26	27	23.7	32	17	.083	.123	.095	.100
7	29.249	29.328	29.606	29.394	24	31	29	25	33	30	29.3	34	24	.117	.151	.149	.139
8	29.831	29.741	29.659	29.744	13	30	24	13	32	25	23.3	35	11	.078	.144	.117	.113
9	29.574	29.515	29.483	29.524	26	35	29	27	38	31	32.0	39	24	.129	.165	.137	.144
10	29.320	29.057	28.937	29.105	34	42	43	36	45	45	42.0	47	31	.170	.238	.251	.216
11	29.360	29.490	29.431	29.427	33	33	29	36	36	32	34.7	46	31	.149	.149	.126	.141
12	29.201	29.231	29.301	29.244	26	31	30	28	32	32	30.7	37	27	.117	.162	.144	.141
13	29.286	29.203	29.267	29.252	29	29	19	30	31	22	27.7	35	21	.149	.137	.069	.118
14	29.542	29.553	29.578	29.558	8	14	13	9	16	14	13.0	26	7	.051	.059	.067	.059
15	29.766	29.730	29.683	29.726	9	18	15	11	21	16	16.0	23	8	.043	.065	.074	.061
16	29.648	29.414	29.172	29.411	16	25	23	18	27	24	23.0	29	12	.067	.112	.112	.097
17	28.909	29.051	29.225	29.062	24	26	18	25	28	19	24.0	30	18	.117	.117	.087	.107
18	29.429	29.413	29.428	29.423	9	19	17	10	20	18	16.0	26	8	.054	.092	.083	.076
19	29.574	29.601	29.672	29.616	11	30	23	12	32	24	22.7	34	10	.061	.144	.112	.106
20	29.777	29.748	29.699	29.741	20	31	26	22	37	29	29.3	38	17	.085	.105	.106	.099
21	29.556	29.415	29.318	29.430	29	33	32	30	34	33	32.3	37	28	.149	.175	.168	.164
22	29.403	29.445	29.488	29.445	30	33	30	31	38	33	34.0	40	30	.155	.123	.132	.137
23	29.563	29.532	29.480	29.525	29	37	33	31	43	36	36.7	45	30	.137	.142	.149	.143
24	29.468	29.312	29.190	29.323	34	38	38	37	43	40	40.0	45	34	.157	.164	.203	.175
25	29.418	29.533	29.614	29.522	32	29	25	33	31	27	30.3	42	27	.168	.137	.112	.139
26	29.677	29.573	29.367	29.539	20	26	24	22	31	26	26.3	33	21	.085	.083	.105	.091
27	29.132	29.061	29.107	29.100	23	27	25	24	28	26	26.0	30	22	.112	.136	.123	.124
28	29.154	29.186	29.219	29.186	21	28	27	23	34	29	28.7	36	20	.090	.085	.124	.100
29	29.252	29.153	29.133	29.179	22	33	29	24	39	31	31.3	40	21	.095	.110	.137	.114
30	29.159	29.113	29.096	29.123	27	33	32	29	35	34	32.7	37	26	.124	.162	.155	.147
31	29.188	29.155	28.985	29.109	31	37	34	39	38	38	36.3	44	30	.151	.207	.144	.167
Means....	29.401	29.372	29.357	29.377	23.4	29.4	26.2	25.0	32.3	28.1	28.5	55	8	.115	.134	.127	.125
April 1	28.716	28.808	28.883	28.802	33	32	33	34	33	35	34.0	43	32	.162	.168	.162	.164
2	29.098	29.300	29.415	29.271	32	35	30	33	40	34	35.7	42	33	.168	.139	.121	.143
3	29.609	29.558	29.409	29.525	27	41	38	29	48	44	41.3	51	25	.124	.166	.151	.147
4	29.211	29.069	29.052	29.111	43	46	42	51	52	43	48.7	57	40	.173	.232	.254	.220
5	28.870	28.875	28.848	28.868	43	36	32	44	38	33	38.3	51	32	.264	.186	.168	.206
6	29.166	29.210	29.123	29.166	26	34	32	30	36	35	33.7	37	26	.095	.170	.142	.136
7	29.137	29.256	29.350	29.248	36	40	37	41	45	40	42.0	48	33	.147	.182	.181	.170
8	29.290	29.322	29.493	29.368	40	41	34	44	43	35	40.7	56	36	.195	.231	.183	.203
9	29.641	29.579	29.430	29.537	31	39	32	32	44	36	37.3	49	27	.162	.173	.129	.155
10	29.280	29.163	29.130	29.128	34	38	35	36	39	36	37.0	44	32	.170	.216	.191	.192
11	29.216	29.200	29.203	29.240	28	33	29	30	26	31	32.3	41	27	.130	.149	.137	.139
12	29.260	29.202	29.166	29.209	32	38	31	36	43	34	37.7	44	30	.129	.164	.139	.144
13	29.280	29.324	29.420	29.341	33	39	36	36	46	40	40.7	53	30	.149	.147	.160	.152
14	29.494	29.403	29.314	29.403	42	54	50	46	69	61	58.7	72	37	.215	.219	.216	.217
15	29.263	29.165	29.089	29.172	44	51	50	50	57	52	53.0	65	50	.209	.295	.336	.278
16	29.059	28.963	28.994	29.005	51	59	48	52	62	50	54.7	63	49	.361	.460	.308	.377
17	29.215	29.322	29.396	29.311	37	48	39	38	58	49	48.3	57	37	.207	.203	.198	.173
18	29.627	29.671	29.635	29.644	35	40	33	41	47	38	42.0	51	34	.126	.156	.123	.135
19	29.535	29.450	29.324	29.436	34	45	41	38	59	46	47.7	63	31	.144	.115	.198	.152
20	29.132	28.932	29.027	29.030	45	44	43	51	47	49	49.0	60	39	.220	.249	.199	.223
21	29.147	29.172	29.095	29.138	38	39	35	41	43	38	40.7	50	36	.190	.186	.165	.180
22	28.833	28.876	29.123	28.944	34	33	33	35	34	35	34.7	40	33	.183	.175	.162	.173
23	29.368	29.488	29.538	29.465	30	34	32	33	37	33	34.3	39	30	.132	.157	.168	.152
24	29.513	29.415	29.445	29.458	32	33	33	35	34	34	34.3	38	29	.142	.175	.175	.164
25	29.543	29.518	29.435	29.499	34	43	34	35	48	38	40.3	49	32	.183	.212	.144	.146
26	29.469	29.307	29.069	29.282	39	49	43	45	56	52	51.0	56	37	.160	.255	.168	.194
27	29.223	29.450	29.461	29.378	33	34	30	35	36	32	34.3	54	32	.162	.170	.144	.159
28	29.551	29.488	29.398	29.479	31	42	34	32	48	37	39.0	54	25	.162	.189	.157	.169
29	29.347	29.210	29.176	29.244	37	51	45	41	55	49	48.3	55	34	.168	.221	.207	.265
30	29.159	29.116	29.099	29.125	46	50	46	48	53	48	49.7	55	47	.294	.321	.294	.303
Means....	29.275	29.260	29.248	29.261	34.7	41.3	37.0	39.1	46.2	40.6	42.0	72	25	.177	.206	.180	.188

the northern and northwestern lakes at Buffalo, New York.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.816	.786	.853	.818	SE....	SW...	SW...	2	2	12	4.7	S. 37 W	10	10	10	.....	.....
.900	.876	.682	.819	W.SW	W.NW	N....	12	12	4	7.7	N. 79 W	10	8	4	.....	.04
.648	.570	.840	.686	NE...	NE...	NE...	4	4	4	4.0	N. 45 E.	10	10	10	.....	.....
.864	.655	.876	.798	W.SW	W....	W.SW	2	4	4	3 3	S. 77 W	10	10	10	.....	.16
.868	.655	.850	.791	SW...	SW...	SW...	2	12	12	8.7	S. 45 W	10	0	0	.....	.....
.840	.876	.644	.787	NE...	NE...	NE...	2	12	12	8.7	N. 45 E.	10	7	10	.....	.....
.872	.800	.890	.854	NE...	W.NW	W....	4	4	2	1.7	N. 31 W	10	10	10	.....	.32
1.000	.794	.872	.889	SW...	E. SE.	NE...	2	2	4	1.0	N. 80 E.	10	9	1	.....	.04
.880	.719	.788	.796	N.....	NE...	NE...	2	2	4	2.7	N. 32 E.	10	10	10	.....	.....
.802	.762	.840	.801	S	S. SW.	SW...	2	4	12	6.0	S. 24 W	10	10	10	.....	.....
.705	.705	.694	.701	SW...	NE...	NE...	4	2	2	.....	.....	10	10	10	.....	.12
.768	.896	.794	.819	NE...	NE...	NW...	4	2	2	2.0	N. 28 E.	10	10	10	.....	.18
.890	.788	.584	.754	NE...	W.SW	W....	2	25	45	21.3	S. 82 W	10	10	9	.....	.08
.784	.659	.816	.753	SW...	SW...	SW...	12	25	45	27.3	S. 45 W	10	10	10	.....	.....
.596	.570	.829	.665	NW...	SW...	W. SW	4	25	2	9.0	S. 55 W	2	10	1	.....	.02
.682	.761	.868	.770	NE...	E. NE.	NE...	2	4	4	3.0	N. 54 E.	10	10	10	.....	.....
.872	.768	.845	.828	SW...	SW...	SW...	2	12	45	19.7	S. 45 W	10	10	10	.....	.16
.791	.850	.840	.827	SW...	SW...	SW...	12	35	4	17.0	S. 45 W	0	10	0	.....	.08
.804	.794	.868	.822	SW...	NW...	NE...	2	2	2	0.7	N. 45 W	0	0	3	.....	.....
.721	.476	.665	.621	NE...	W. SW	NE...	2	12	12	2.0	N. 12 W	0	10	10	.....	.....
.890	.895	.893	.893	NE...	N.....	NE...	12	4	4	6.3	N. 37 E.	10	10	10	.....	.....
.893	.537	.703	.711	NE...	NE...	NE...	4	2	2	2.7	N. 45 E.	10	10	10	.....	1.82
.788	.511	.705	.668	NE...	NE...	NW...	2	2	2	1.7	N. 16 E.	10	10	10	.....	.08
.712	.587	.820	.706	SE....	SE....	SW. S.	2	2	12	4.3	S. 15 W	10	10	10	.....	.....
.893	.788	.761	.814	W.SW	NW...	NW...	2	2	4	2.3	N. 61 W	10	10	10	.....	.22
.721	.480	.754	.652	NE...	NE...	NE...	2	4	4	3.3	N. 45 E.	10	10	10	.....	.....
.868	.883	.876	.876	N.....	N.....	N.....	4	2	2	2.7	North..	10	10	10	.....	.04
.730	.432	.775	.646	W.byN	W.byN	NW...	2	4	2	2.3	N. 49 W	6	2	0	.....	.08
.738	.463	.788	.663	W....	W.NW	W.NW	2	25	4	10.0	N. 67 W	1	0	0	.....	.....
.775	.797	.792	.788	W.SW	W.SW	SW.W	12	35	4	17.0	S. 66 W	2	10	5	.....	.....
.800	.905	.628	.778	SW...	SW...	SW...	4	12	2	6.0	N. 45 W	0	0	4	.....	.....
.803	.712	.788	.768	.....	.....	.....	....	....	....	3.8	S. 67 W	7.8	8.2	7.3	.....	3.44
.896	.893	.797	.862	SW. W	W. SW	W. SW	45	45	24	38.0	S. 63 W	10	10	10	.....	.32
.893	.557	.617	.689	W.SW	W. SW	NW...	25	12	4	13.0	S. 73 W	4	9	0	.....	.06
.775	.494	.522	.597	SW..	E.....	E.....	2	2	2	1.7	S. 73 E.	6	10	0	.....	.....
.461	.598	.916	.658	SW..	SW..	SW..	12	12	2	8.7	S. 45 W	10	10	10	.....	.....
.918	.811	.893	.907	SW..	SW..	SW..	4	25	12	13.7	S. 45 W	10	4	10	.....	.46
.569	.802	.698	.690	W.byN	W.SW	W.SW	4	25	4	10.7	S. 71 W	0	10	0	.....	.12
.567	.607	.732	.635	SW..	W.SW	E.....	12	25	2	9.3	S. 50 W	10	7	10	.....	.....
.677	.833	.898	.803	SE....	W.SW	W....	2	12	2	4.3	S. 62 W	10	10	0	.....	.....
.896	.597	.610	.701	SW..	SW..	SW..	2	4	2	2.7	S. 45 W	10	0	3	.....	.06
.802	.907	.900	.870	NE...	NE...	NE...	2	2	2	2.0	N. 45 E.	10	10	10	.....	.....
.782	.705	.788	.758	N.byW	W.SW	W.SW	2	12	4	5.3	S. 72 W	10	1	0	.....	.74
.610	.587	.712	.636	W.SW	W.SW	SW.W	12	12	4	9.3	S. 66 W	0	0	0	.....	.....
.705	.471	.645	.607	NE...	NE...	NE...	2	4	12	6.0	N. 45 E.	0	3	0	.....	.....
.691	.309	.402	.467	NE...	NE...	NE...	2	4	4	3.3	N. 45 E.	10	10	10	.....	.....
.581	.634	.861	.692	S	S	S	4	4	2	3.3	South..	10	10	10	.....	.....
.930	.828	.856	.871	N. by E	N. NW	N.....	2	12	4	6.0	N. 14 W	10	10	10	.....	.24
.905	.421	.307	.544	NW...	NW..	NW...	2	4	2	2.7	N. 45 W	1	0	0	.....	.....
.488	.483	.537	.503	NW...	NW..	W. SW	4	4	2	3.0	N. 58 W	0	1	2	.....	.....
.628	.229	.617	.491	E. by N	W.SW	NW...	2	2	2	0.7	N. 59 W	10	10	10	.....	.....
.590	.772	.572	.645	S	SW..	W.SW	2	12	12	8.3	S. 52 W	10	10	10	.....	.....
.738	.669	.719	.709	W.SW	W.SW	S	4	12	2	5.7	S. 61 W	10	1	0	.....	.....
.898	.895	.797	.863	NE...	NW...	NW...	12	4	4	5.0	N. 8 E	10	10	10	.....	.....
.703	.712	.893	.769	NW...	SW..	NW...	4	4	2	2.7	N. 80 W	10	10	4	.....	.62
.698	.895	.895	.829	E. SE.	NE...	W. SW	4	4	4	1.0	S. 758..	10	10	10	.....	.14
.898	.631	.628	.719	SW..	SW..	SW...	4	12	4	6.7	S. 45 W	10	6	1	.....	.....
.533	.569	.411	.504	SW..	SW..	SW...	12	4	12	9.3	S. 45 W	10	9	1	.....	.28
.797	.892	.794	.798	NW...	NW...	S	12	4	2	5.0	N. 51 W	10	10	1	.....	.....
.896	.563	.712	.724	E.....	NE...	NE...	2	4	4	3.0	N. 54 E.	1	0	0	.....	.22
.653	.743	.710	.702	SE....	S. SW.	S	2	4	4	3.0	S. 1 W.	10	10	10	.....	.....
.850	.798	.850	.833	SW..	SW..	SW...	2	2	2	2.0	S. 45 W	10	10	10	.....	.10
.734	.660	.709	.701	.....	.....	.....	....	....	....	4.4	S. 65 W	7.5	7.0	5.1	.....	3.36

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
May 1	28.953	29.040	29.093	29.029	38	39	36	39	40	39	39.3	51	37	.216	.225	.173	.205
2	29.373	29.495	29.586	29.485	29	35	26	31	38	30	33.0	42	28	.137	.165	.093	.132
3	29.754	29.726	29.660	29.713	25	37	32	27	45	36	36.0	46	23	.112	.116	.129	.119
4	29.557	29.285	29.251	29.364	36	50	47	41	57	51	49.7	63	32	.147	.268	.270	.228
5	29.154	29.191	29.208	29.184	48	50	49	54	51	52	52.3	56	43	.256	.348	.308	.304
6	29.232	29.246	29.187	29.222	42	44	39	43	45	41	43.0	53	39	.254	.275	.218	.249
7	29.207	29.172	29.165	29.181	38	43	36	41	47	38	42.0	51	36	.190	.225	.186	.200
8	29.075	28.947	28.922	28.981	36	44	41	38	49	43	43.3	50	36	.186	.223	.231	.213
9	28.887	28.933	28.995	28.938	39	38	36	41	39	38	39.3	45	37	.212	.216	.193	.207
10	29.067	29.122	29.135	29.115	38	42	36	41	47	38	42.0	47	34	.190	.202	.186	.192
11	29.257	29.296	29.292	29.282	37	42	37	41	45	39	41.7	46	32	.168	.228	.194	.197
12	29.266	29.458	29.386	29.370	41	45	41	45	52	45	47.3	54	32	.205	.207	.205	.206
13	29.324	29.076	28.899	29.100	38	49	50	42	53	52	49.0	57	40	.177	.295	.334	.268
14	28.867	28.897	28.927	28.897	40	43	40	41	45	41	42.3	53	39	.235	.251	.233	.240
15	28.870	28.895	29.020	28.928	39	41	42	40	42	44	42.0	46	37	.225	.244	.241	.237
16	29.132	29.164	29.162	29.153	40	46	42	43	50	43	45.3	51	39	.208	.238	.254	.233
17	29.228	29.276	29.436	29.313	43	43	42	48	45	45	46.0	51	40	.212	.251	.232	.232
18	29.506	29.496	29.484	29.495	41	45	41	45	49	42	45.3	52	38	.205	.247	.244	.232
19	29.471	29.400	29.338	29.403	44	50	35	47	59	37	47.7	60	37	.249	.242	.176	.222
20	29.231	29.268	25.216	29.238	45	48	46	47	52	49	49.3	52	46	.273	.282	.271	.275
21	29.137	28.934	28.804	28.958	40	51	49	49	54	50	51.0	57	43	.130	.335	.332	.265
22	28.782	28.809	28.820	28.804	49	46	43	51	48	44	47.7	52	43	.321	.289	.264	.291
23	28.815	28.982	29.060	28.959	40	43	42	42	43	44	43.0	44	40	.221	.278	.241	.247
24	29.254	29.263	29.253	29.257	44	50	45	46	54	50	50.0	54	42	.262	.308	.284	.285
25	29.223	29.121	29.059	29.134	47	55	51	54	63	52	56.3	67	46	.231	.387	.361	.326
26	29.137	29.195	29.301	29.211	46	50	45	49	53	47	49.7	67	44	.271	.331	.273	.292
27	29.439	29.445	29.428	29.437	43	54	47	44	57	52	51.0	58	37	.264	.378	.257	.300
28	29.423	29.199	29.178	29.267	46	60	49	50	63	52	55.0	66	47	.258	.478	.308	.348
29	29.185	29.232	29.251	29.223	51	56	49	53	58	51	54.0	59	48	.348	.402	.321	.357
30	29.313	29.328	29.298	29.313	48	50	49	50	52	52	51.3	54	47	.309	.334	.308	.317
31	29.462	29.498	29.456	29.472	41	49	43	43	52	45	46.7	53	42	.231	.308	.251	.263
Means....	29.220	29.213	29.209	29.214	41.0	46.4	42.1	45.5	51.6	46.1	47.7	67	28	.230	.285	.251	.255
June 1	29.408	29.230	29.186	29.275	39	69	59	52	74	64	63.3	78	41	.068	.641	.433	.381
2	29.133	28.988	28.888	29.003	58	63	62	62	67	64	64.3	78	41	.429	.592	.529	.483
3	28.886	28.952	29.019	28.952	59	56	50	61	58	52	57.0	65	51	.473	.422	.334	.410
4	29.203	29.219	29.265	29.296	32	60	51	54	63	53	56.7	65	49	....	.478	.348	.413
5	29.395	29.411	29.312	29.373	52	60	58	53	70	62	61.7	71	47	.373	.385	.429	.396
6	29.314	29.270	29.236	29.273	59	67	63	65	78	68	70.3	79	54	.420	.514	.509	.481
7	29.293	29.277	29.329	29.300	64	73	59	69	83	63	71.7	84	61	.529	.677	.447	.551
8	29.394	29.411	29.392	29.399	54	58	58	61	70	62	64.3	72	58	.325	.323	.424	.358
9	29.489	29.438	29.452	29.460	58	60	55	63	75	62	63.3	77	52	.416	.318	.340	.358
10	29.506	29.487	29.438	29.477	57	61	59	64	79	67	70.0	81	51	.373	.296	.393	.354
11	29.481	29.430	29.325	29.412	66	63	59	70	78	72	73.3	81	59	.586	.375	.327	.429
12	29.350	29.349	29.334	29.344	57	61	59	59	63	61	61.0	73	58	.439	.510	.473	.474
13	29.447	29.423	29.392	29.421	58	63	59	60	69	62	63.7	71	56	.456	.495	.460	.470
14	29.453	29.337	29.303	29.364	61	70	64	69	83	69	73.7	84	58	.431	.558	.529	.506
15	29.283	29.250	29.196	29.243	66	63	66	73	74	68	71.7	74	65	.545	.429	.612	.529
16	29.231	29.345	29.358	29.311	64	69	65	66	72	67	68.3	75	64	.569	.668	.581	.606
17	29.411	29.332	29.263	29.335	67	74	67	70	81	73	74.7	82	61	.622	.745	.581	.649
18	29.301	29.366	29.462	29.376	64	61	52	66	68	58	64.0	78	57	.569	.543	.398	.503
19	29.557	29.543	29.517	29.539	54	60	56	60	69	60	63.0	70	40	.338	.398	.306	.347
20	29.522	29.533	29.522	29.526	56	63	56	58	73	58	63.0	76	51	.422	.443	.422	.429
21	29.577	29.502	29.488	26.522	58	69	62	60	81	67	69.3	82	53	.456	.547	.489	.497
22	29.491	29.439	29.431	29.454	61	70	66	66	86	70	74.0	86	59	.470	.518	.526	.505
23	29.433	29.343	29.345	29.374	63	71	69	69	88	72	76.3	90	65	.495	.610	.668	.591
24	29.295	29.221	29.210	29.242	67	75	70	72	89	74	78.3	90	64	.595	.678	.679	.650
25	29.202	29.182	29.223	29.202	70	76	67	77	81	73	77.0	88	68	.639	.829	.581	.683
26	29.283	29.288	29.308	29.293	67	71	68	73	75	71	73.0	76	65	.581	.704	.644	.643
27	29.301	29.219	29.231	29.250	67	72	67	70	82	70	74.0	83	64	.625	.650	.625	.633
28	29.389	29.435	29.486	29.437	59	68	61	63	72	64	66.3	72	62	.447	.631	.497	.525
29	29.497	29.405	29.296	29.399	58	63	63	60	72	68	66.7	73	51	.456	.455	.508	.473
30	29.161	29.042	29.042	29.082	68	69	68	70	78	70	72.7	81	68	.658	.582	.658	.633
Means....	29.356	29.322	29.308	29.329	59.4	66.0	61.3	64.5	75.0	65.5	68.3	90	40	.476	.531	.494	.501

the northern and northwestern lakes at Buffalo, New York.

VAPOR.				WIND.							Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.						
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.907	.910	.726	.848	NW..	NW..	NW..	12	12	4	9.3	N.45 W.	10	10	0	.....	.52
.788	.719	.569	.692	NW..	NW..	NW..	2	4	2	2.7	N.45 W.	10	9	0	.....	.54
.761	.386	.610	.586	NE...	NE...	NW..	3	2	4	1.9	North..	0	0	4	.....	.....
.567	.577	.722	.622	NE...	SE....	S	4	12	12	7.0	S. 33 E.	10	10	10	.....	.....
.613	.929	.794	.779	S	S	S	12	12	12	12.0	South..	10	10	10	.....	.....
.916	.920	.824	.887	SW..	SW..	SW..	2	2	2	2.0	S. 45 W.	10	10	4	.....	.22
.738	.698	.811	.749	W.SW	W.SW	SW..	2	2	4	2.7	S. 57 W.	3	10	10	.....	.22
.811	.638	.833	.761	N.NW.	N.NW.	NW..	4	12	12	9.3	N.32 W.	10	10	10	.....	.....
.894	.907	.903	.878	NW..	W.SW	SW..	4	12	4	5.7	S. 75 W.	10	10	10	.....	.10
.738	.624	.811	.724	SW..	SW..	SW..	4	4	2	3.3	S. 45 W.	10	7	1	.....	.06
.653	.762	.816	.744	SW..	SW..	SW..	4	12	2	6.0	S. 45 W.	1	1	0	.....	.....
.684	.535	.684	.634	SW..	SW..	NE ...	4	12	2	4.7	N.45 W.	0	0	9	.....	.....
.661	.733	.861	.752	NE ...	NE ...	NE ..	4	4	2	3.3	N. 45 E.	10	10	10	.....	.....
.912	.840	.912	.888	W.SW	W.SW	W.SW	4	12	12	9.3	S. 67 W.	10	10	10	.....	.30
.910	.914	.836	.887	W.SW	SW..	NW..	2	4	4	2.3	S. 85 W.	10	10	10	.....	.....
.750	.716	.916	.794	SW..	SW..	SW..	2	4	4	3.3	S. 45 W.	1	0	10	.....	.20
.631	.840	.762	.744	SW..	SW..	NW..	2	2	2	1.7	S. 74 W.	8	10	5	.....	.....
.684	.710	.914	.769	NW..	SW..	SW..	4	4	2	2.6	S. 80 W.	10	9	1	.....	.....
.772	.484	.807	.688	NE ...	NW..	NE ...	2	4	4	2.6	N. 10 E.	10	10	10	.....	.....
.847	.727	.781	.785	NE ...	NE ...	E	2	2	2	1.7	N. 56 E.	10	10	8	.....	.46
.373	.802	.927	.701	NE ...	NE ...	NE ...	4	12	12	9.3	N. 45 E.	10	10	10	.....	.....
.859	.850	.918	.876	SW..	SW..	SW..	4	4	25	11.0	S. 45 W.	10	10	10	.....	.34
.829	1.000	.836	.888	SW..	SW..	SW..	35	25	12	24.0	S. 45 W.	10	10	10	.....	.20
.843	.738	.646	.742	W.SW	SW..	NE ...	4	4	2	2.0	S. 61 W.	4	6	0	.....	.20
.552	.568	.930	.683	S.SE..	S	W.SW	4	25	12	11.7	S. 16 W.	0	9	10	.....	.....
.781	.798	.847	.809	SW..	SW..	SE....	4	12	2	5.3	S. 38 W.	10	3	0	.....	.18
.918	.812	.660	.797	S	W.SW	NE ...	2	2	2	0.7	S. 13 W.	0	10	0	.....	.....
.716	.831	.794	.780	NE ...	NE ...	NE ..	4	4	12	6.7	N. 45 E.	10	10	8	.....	.....
.864	.876	.859	.866	N	W.SW	W.SW	2	4	4	2.7	S. 83 W.	10	4	1	.....	.24
.856	.861	.794	.837	SW..	SW..	SW..	2	4	2	2.7	S. 45 W.	10	10	10	.....	.....
.833	.794	.840	.822	N.NW.	W.SW	N.NE.	4	4	2	1.3	N.58 W.	10	3	0	.....	.....
.786	.770	.831	.796	.....	.....	.....	....	....	....	2.7	S. 55 W.	7.6	7.8	6.2	.....	3.78
.175	.764	.727	.555	NE ...	NE ...	NE ...	2	4	4	3.2	N. 45 E.	3	6	1	.....	.....
.772	.790	.888	.817	S	S	NE ...	2	12	2	4.3	S. 6 E..	10	10	10	.....	.06
.682	.876	.861	.873	SW..	SW..	SW..	4	35	12	17.0	S. 45 W.	10	8	10	.....	.36
.....	.831	.864	.847	SW..	SW..	SW..	12	4	4	6.0	S. 45 W.	9	8	0	.....	.....
.932	.525	.772	.743	W.SW	W.SW	E.SE.	2	4	2	1.7	S. 52 W.	10	1	10	.....	.16
.680	.537	.743	.653	W.SW	W.SW	NW..	4	4	2	3.0	S. 79 W.	6	9	0	.....	.....
.747	.600	.776	.708	SW..	NE ...	NE ...	2	4	12	4.7	N. 45 E.	1	10	9	.....	.....
.806	.441	.772	.606	NE ...	NE ...	NE ...	12	25	4	13.7	N. 45 E.	10	10	0	.....	.....
.723	.367	.612	.567	NE ...	NE ...	NE ...	2	4	2	2.6	N. 45 E.	1	0	0	.....	.....
.625	.300	.505	.507	NE ...	S.SE..	E.by N	2	4	2	1.7	S. 76 E.	1	0	0	.....	.....
.799	.392	.417	.536	SW..	SW..	SW..	2	4	4	3.2	S. 45 W.	1	3	9	.....	.....
.878	.886	.882	.882	SW..	SW..	SW..	12	12	12	12.0	S. 45 W.	10	10	10	.....	.04
.880	.700	.828	.803	SW..	SW..	SW..	4	4	2	3.2	S. 45 W.	1	0	1	.....	.....
.607	.495	.747	.616	SW..	SW..	SW..	2	4	2	2.6	S. 45 W.	1	2	7	.....	.....
.672	.511	.895	.693	SW..	SW..	SW..	2	4	4	3.2	S. 45 W.	10	6	10	.....	.04
.891	.852	.893	.879	W.SW	W.SW	SW..	2	4	2	2.3	S. 63 W.	10	10	0	.....	.20
.848	.704	.716	.756	NE ...	SW..	NE ...	2	2	2	0.7	N. 45 E.	10	2	10	.....	.....
.891	.793	.641	.775	S	W.SW	NW..	2	12	4	4.7	S. 75 W.	10	6	0	.....	.10
.653	.564	.765	.661	NW..	W.SW	W.SW	2	4	4	3.0	S. 79 W.	0	0	0	.....	.....
.876	.545	.876	.766	SE....	W.SW	E.NE.	2	2	2	0.7	S. 45 E.	10	10	3	.....	.....
.880	.518	.740	.713	SW..	W.NW	E.NE.	2	2	2	0.3	N. 78 W.	4	10	2	.....	.....
.735	.417	.799	.684	SW..	W	W.SW	2	2	2	2.0	S. 69 W.	6	3	0	.....	.....
.700	.539	.852	.704	SW..	NE ...	SW..	4	4	2	0.7	S. 45 W.	3	10	3	.....	.....
.758	.497	.810	.688	SE....	SE....	SE....	2	2	2	2.0	S. 45 E.	6	4	2	.....	.....
.669	.784	.716	.730	SE....	SE....	SE....	2	2	12	5.3	S. 45 E.	3	9	6	.....	.....
.716	.812	.850	.793	S	S	S	2	2	2	2.0	South..	9	10	1	.....	.20
.848	.595	.848	.764	S	SW..	SW..	2	2	35	13.0	S. 43 W.	1	9	10	.....	.40
.776	.804	.833	.804	W.NW	W.SW	W.SW	12	4	2	5.7	N 83 W.	10	10	1	.....	.....
.880	.582	.743	.735	SW..	SW..	SW..	2	4	4	3.2	S. 45 W.	4	0	2	.....	.....
.898	.613	.898	.803	SW..	SW..	W	35	45	2	27.0	S. 46 W.	3	5	9	.....	.....
.759	.622	.778	.722	.....	.....	.....	....	....	....	3.0	S. 44 W.	5.8	6.0	4.2	.....	1.56

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
July 1	29.251	29.247	29.263	29.254	63	76	67	66	79	69	71.3	80	58	.536	.856	.635	.676
2	29.337	29.298	29.281	29.305	51	71	64	60	75	70	68.3	76	54	.255	.704	.516	.492
3	29.243	29.240	29.183	29.222	69	73	59	73	78	73	74.7	83	60	.655	.744	.447	.615
4	29.170	29.112	29.183	29.155	70	73	67	74	77	69	73.3	81	68	.679	.757	.635	.691
5	29.252	29.159	29.133	29.181	61	74	70	62	82	73	72.3	82	61	.523	.731	.693	.649
6	29.053	29.102	29.246	29.134	73	71	65	76	74	68	72.7	77	68	.771	.718	.577	.689
7	29.243	29.255	29.324	29.274	68	69	62	73	76	65	71.3	77	65	.618	.614	.516	.583
8	26.414	29.398	29.409	29.407	55	64	59	61	75	63	66.3	76	50	.354	.449	.447	.417
9	29.405	29.398	29.453	29.419	55	58	56	57	67	57	60.3	67	55	.407	.363	.436	.402
10	29.510	29.441	29.361	29.404	58	63	60	59	70	66	65.0	72	49	.469	.482	.438	.463
11	29.261	29.224	29.238	29.241	61	69	70	70	80	71	73.7	81	64	.516	.561	.720	.599
12	29.286	29.292	29.387	29.322	61	75	55	64	81	56	67.0	81	56	.497	.787	.420	.568
13	29.537	29.593	29.575	29.568	55	57	53	60	69	57	62.0	70	51	.367	.306	.350	.341
14	29.614	29.554	29.528	29.565	58	75	62	65	80	67	70.7	81	46	.389	.800	.489	.559
15	29.463	29.319	29.298	29.360	61	70	66	69	82	67	72.7	85	56	.430	.572	.626	.543
16	29.390	29.385	29.434	29.403	56	68	59	59	72	65	65.3	73	54	.409	.631	.490	.497
17	29.504	29.483	29.501	29.496	58	68	64	61	73	66	66.7	75	51	.443	.648	.589	.553
18	29.486	29.462	29.451	29.466	60	66	60	68	77	66	70.3	78	52	.411	.492	.438	.447
19	29.457	29.420	29.414	29.430	58	69	56	60	74	61	65.0	74	55	.456	.641	.383	.493
20	29.482	29.375	29.371	29.409	60	70	66	62	76	70	69.3	78	55	.491	.652	.586	.576
21	29.288	29.192	29.194	29.225	64	79	62	71	81	65	72.3	80	60	.503	.963	.516	.661
22	29.231	29.195	29.223	29.216	66	71	67	70	76	69	71.7	77	63	.586	.691	.635	.637
23	29.305	29.290	29.283	29.293	69	75	69	72	78	73	74.3	80	66	.668	.827	.655	.717
24	29.308	29.230	29.228	29.255	69	74	70	71	78	71	73.3	82	68	.622	.785	.720	.729
25	29.213	29.193	29.148	29.185	67	70	70	69	73	71	71.0	75	69	.635	.693	.720	.683
26	29.133	29.157	29.221	29.170	68	71	65	69	79	70	72.7	81	54	.671	.651	.550	.624
27	29.245	29.192	29.192	29.210	68	72	73	72	81	77	76.7	85	60	.631	.663	.757	.684
28	29.178	29.082	29.097	29.119	73	76	71	75	81	72	76.0	82	73	.784	.829	.745	.786
29	29.248	29.305	29.409	29.321	62	63	57	67	72	63	67.3	74	63	.489	.455	.386	.443
30	29.492	29.467	29.497	29.483	58	69	56	62	74	60	65.3	75	54	.429	.641	.396	.489
31	29.454	29.367	29.283	29.368	56	71	59	61	79	69	69.7	80	51	.383	.651	.367	.467
Means....	29.337	29.304	29.316	29.319	62.4	65.5	63.2	66.4	76.4	67.1	70.0	85	46	.521	.657	.542	.574
Aug. 1	29.245	29.186	29.153	29.195	68	65	64	72	68	69	69.7	76	65	.631	.577	.529	.579
2	29.136	29.175	29.223	29.178	64	71	64	68	76	69	71.0	77	66	.543	.691	.529	.588
3	29.381	29.410	29.444	29.412	61	63	62	66	74	65	68.3	74	60	.470	.429	.516	.472
4	29.486	29.495	29.491	29.491	60	72	66	64	76	70	70.0	77	59	.465	.731	.586	.594
5	29.515	29.510	29.493	29.506	65	74	69	72	78	73	74.3	79	66	.524	.785	.655	.655
6	29.478	29.419	29.465	29.454	65	74	70	67	82	72	73.7	83	65	.591	.731	.706	.676
7	29.460	29.399	29.405	29.421	70	75	70	74	86	72	77.3	86	64	.679	.719	.706	.701
8	29.398	29.321	29.353	29.358	70	74	69	75	85	73	77.3	86	63	.666	.691	.668	.675
9	29.371	29.357	29.340	29.356	68	73	70	70	83	74	75.7	74	65	.658	.677	.679	.671
10	29.381	29.434	29.504	29.440	67	69	58	70	80	65	71.7	80	66	.652	.561	.389	.534
11	29.586	29.492	29.504	29.527	62	69	60	64	81	65	70.0	82	55	.529	.547	.451	.509
12	29.401	29.269	29.183	29.285	58	69	67	65	82	73	73.3	82	53	.389	.534	.581	.501
13	29.047	29.080	29.135	29.087	72	72	71	76	75	72	74.3	76	69	.731	.744	.745	.740
14	29.271	29.337	29.392	29.333	65	74	57	66	79	62	69.0	79	62	.604	.772	.399	.592
15	29.406	29.442	29.412	29.420	60	63	61	64	81	62	69.0	81	54	.465	.335	.523	.441
16	29.326	29.245	29.236	29.269	64	69	64	68	76	68	70.7	77	61	.543	.614	.543	.567
17	29.168	29.160	29.080	29.136	65	72	64	67	78	71	72.0	79	60	.591	.704	.503	.599
18	29.155	29.142	29.163	29.153	69	73	68	76	81	73	76.7	82	69	.614	.703	.618	.645
19	29.311	29.313	29.346	29.323	59	66	59	66	73	64	67.7	75	61	.407	.545	.641	.531
20	29.412	29.333	29.369	29.388	56	65	62	62	73	63	66.0	73	57	.369	.510	.542	.474
21	29.411	29.274	29.296	29.327	61	72	61	66	80	68	71.3	81	53	.470	.677	.443	.530
22	29.334	29.252	29.238	29.275	58	70	61	61	81	67	69.7	82	57	.443	.585	.457	.495
23	29.214	29.114	29.123	29.150	59	72	66	61	80	73	71.3	80	55	.473	.677	.545	.565
24	29.216	29.202	29.352	29.257	61	65	56	68	77	62	69.0	77	63	.443	.591	.389	.488
25	29.474	29.472	29.501	29.482	57	62	60	61	77	66	68.0	78	47	.412	.489	.436	.446
26	29.504	29.406	29.355	29.422	59	72	60	65	87	76	76.0	87	53	.490	.582	.395	.489
27	29.368	29.209	29.175	29.251	63	73	67	71	86	76	77.7	86	69	.469	.636	.542	.549
28	29.085	29.152	29.112	29.116	69	73	63	73	77	70	73.3	77	70	.655	.757	.468	.693
29	29.259	29.231	29.265	29.252	58	59	55	63	66	57	62.0	72	56	.416	.407	.407	.410
30	29.446	29.499	29.515	29.487	47	53	52	49	63	57	56.3	63	46	.297	.270	.322	.296
31	29.470	29.293	29.226	29.330	49	56	60	55	69	64	62.7	70	46	.289	.276	.465	.337
Means....	29.346	29.312	29.318	29.325	62.2	68.7	63.1	66.3	76.4	68.1	70.3	87	46	.512	.602	.525	.546

the northern and northwestern lakes at Buffalo, New York.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.838	.865	.896	.866	E.NE.	SW ...	S. SW	2	2	2	0.7	S. 11 W.	3	9	10	.....	.....
.493	.812	.704	.700	W. SW	W	W. SW	2	2	2	2.0	S. 75 W.	1	0	1	.....	.....
.807	.776	.776	.786	SW ..	SW ...	SW ...	2	2	4	2.7	S. 45 W.	5	6	2	.....	.....
.810	.817	.896	.841	W. SW	SW ...	NE....	2	2	4	0.3	N. 42 W.	10	10	10	.....	.....
.942	.669	.854	.822	NE	NE....	NE....	2	2	2	2.0	N. 45 E.	10	9	9	.....	.18
.860	.836	.843	.853	SW ...	SW ...	SW ...	4	12	2	6.0	S. 45 W.	10	10	9	.....	.04
.761	.685	.836	.761	W. SW	W by S	S. SW.	12	2	2	5.0	S. 63 W.	6	9	1	.....	.....
.659	.518	.776	.651	SE	W. SW	W. SW	2	2	2	1.3	S. 41 W.	4	8	10	.....	.....
.874	.550	.936	.787	NE	NE	NE....	4	4	2	3.3	N. 45 E.	10	4	0	.....	.26
.939	.658	.685	.761	S. SE..	S. SW.	SE....	2	2	2	2.0	S. 13 E.	7	9	9	.....	.....
.704	.548	.949	.734	SW ...	SW ...	SW ...	4	4	12	6.7	S. 45 W.	6	8	10	.....	.....
.833	.744	.935	.837	W. NW	N	NE....	2	2	2	1.3	N. 6 W.	10	10	10	.....	.34
.708	.432	.752	.631	NE	NE	NE....	2	4	2	2.7	N. 55 E.	0	0	0	.....	.....
.631	.782	.740	.718	E	E. NE.	NE....	2	2	2	2.0	N. 69 E.	0	0	0	.....	.....
.607	.524	.946	.692	SW ...	SW ...	SW ...	2	2	4	2.7	S. 45 W.	5	10	10	.....	.....
.819	.804	.680	.768	NW ...	NW ...	NW ...	2	2	2	2.0	N. 45 W.	1	3	5	.....	.44
.825	.761	.891	.826	NW ...	W. SW	W. SW	2	2	2	1.3	S. 87 W.	1	8	4	.....	.....
.601	.531	.685	.6 6	NW ...	NW ...	NW ...	2	2	2	2.0	N. 45 W.	2	9	5	.....	.....
.680	.764	.713	.786	NE	NE	NE....	2	2	2	2 0	N. 45 E	8	3	2	.....	.....
.884	.727	.799	.803	NE	NE	NE....	4	4	2	3.3	N. 45 E	9	10	10	.....	.....
.663	.911	.836	.803	W. SW	W. SW	NW ...	2	2	4	2.3	N. 80 W.	0	10	10	.....	.....
.799	.771	.896	.822	W	W	W	2	2	2	2.0	West...	10	4	0	.....	.08
.852	.863	.807	.841	SW ...	SW ...	SW ...	4	4	2	3.3	S. 45 W.	0	7	0	.....	.....
.899	.819	.949	.889	SW ...	SW ...	SW	4	12	2	6.0	S. 45 W.	8	9	6	.....	.....
.896	.854	.949	.700	S. SW.	W. SW	NE....	4	2	2	1.3	S. 28 W.	10	10	10	.....	.36
.947	.667	.751	.785	SE....	E. NE.	SE....	2	4	2	2.3	S. 79 E.	10	9	2	.....	.18
.804	.627	.817	.749	W.....	W	W	4	4	2	3.3	West...	7	4	0	.....	.....
.904	.784	.950	.879	SW ...	SW ...	SW ...	12	4	12	9.3	S. 45 W.	10	9	10	.....	.....
.740	.582	.670	.664	NW ...	NW ...	NW ...	4	4	2	3.3	N. 45 W.	8	6	2	.....	.10
.772	.764	.765	.767	NW ...	NW ...	NW ...	4	4	2	3.3	N. 45 W.	1	3	5	.....	.....
.713	.657	.518	.629	S	S	S	12	4	25	13.7	South ..	10	9	10	.....	.....
.789	.713	.813	.772	.....	.....	.....	....	....	....	1.5	S. 52 W.	5.9	6.9	5.6	.....	1.98
.804	.843	.747	.798	S.....	S	S	12	2	25	13.0	South ..	10	10	10	.....	.....
793	.771	.747	.770	S	S. SW.	NW ...	12	12	4	7.3	S. 20 W.	10	6	6	.....	.26
.735	.511	.836	.694	N. NW	W	W. SW	4	4	2	2.7	N. 67 W.	9	2	0	.....	.....
.780	.815	.799	.798	SW ...	SW ...	SW ...	2	4	2	2.7	S. 45 W.	2	3	1	.....	.....
.668	.819	.807	.765	SW ...	SW ...	SW ...	4	2	2	2.7	S. 45 W.	0	6	0	.....	.....
.893	.669	.900	.821	S. SW .	W. SW	W. SW	2	4	2	2.7	S. 59 W.	10	10	9	.....	.....
.810	.579	.900	.763	SW ...	SW ...	SW ...	2	2	2	2.0	S. 45 W.	9	8	10	.....	.....
.768	.574	.852	.731	SW ...	SW	SW ...	2	2	2	2.0	S. 45 W.	8	9	0	.....	.02
.898	.600	.810	.769	S. SW .	W. SW	SW ...	2	12	4	5.7	S. 57 W.	0	3	4	.....	.....
.848	.548	.631	.676	W.....	NW ...	N. NW	2	4	2	2.3	N. 49 W.	10	3	0	.....	.....
.888	.518	.731	.712	NE....	NE	NE	2	4	2	2.7	N. 45 E.	3	5	0	.....	.....
.631	.489	.716	.612	E. SE.	W. SW	W	2	4	4	2.0	S. 67 W.	0	5	5	.....	.....
.815	.858	.950	.874	SW ...	SW ...	SW	25	4	2	10.3	S. 45 W.	10	10	10	.....	.....
.945	.779	.718	.914	NW ...	NW ...	NW	2	4	2	2.7	N. 45 W.	10	8	0	.....	.....
.780	.317	.942	.680	N	NE	E. NE.	2	4	2	2.3	N 40 E	9	8	0	.....	.....
.793	.685	.793	.757	NE....	NE	NE	4	25	2	10.3	N. 45 E	10	10	10	.....	.....
.893	.734	.663	.763	W. NW	W. SW	NE by E	2	4	2	1.3	N. 80 W.	5	8	1	.....	.....
.685	.665	.761	.704	W. SW	W. SW	SW ...	12	35	25	23.7	S. 60 W.	0	4	2	.....	.08
.636	.672	.764	.691	NW ..	W. SW	N. NW	12	4	2	5.3	N. 56 W.	4	10	0	.....	.....
.665	.629	.942	.745	NE	SW ...	NE	2	4	2	.....	.....	10	9	0	.....	.....
.735	.681	.647	.681	S. SE..	W. SW	NE	2	4	2	0.7	S. 43 W.	3	9	3	.....	.....
.825	.554	.690	.690	NE	NE	NE	2	2	2	2.0	N. 45 E	8	10	0	.....	.....
.882	.661	.672	.738	E	W. SW	SW ...	2	2	2	1.0	S. 24 W.	3	9	1	.....	.....
.647	.893	.665	.735	NW ...	W. SW	N.	4	4	12	5.0	N. 26 W.	10	7	0	.....	.....
.769	.740	.685	.731	NE	SW	NE	2	2	2	0.7	N. 45 E	0	0	0	.....	.....
.680	.454	.340	.491	S	S. SW.	SE....	2	2	12	5.0	S. 31 E.	10	9	0	.....	.....
.618	.513	.603	.578	SW ...	SW	S	4	4	12	6.0	S. 18 W.	3	4	0	.....	.....
.807	.817	.658	.761	SW ...	SW ...	NE....	12	12	2	7.3	S. 45 W.	10	10	0	.....	.....
.723	.636	.874	.744	NW ...	NW ...	NW ...	4	2	4	3.2	N. 45 W.	2	10	10	.....	.....
.853	.470	.692	.672	N. NW	W	.....	4	4	....	2.3	N. 58 W.	1	9	3	.....	.08
.620	.391	.780	.597	SE....	S	W. SW	12	12	12	8.7	S. 5 W.	4	10	10	.....	.....
.771	.640	.752	.721	.....	.....	.....	....	....	....	2.5	S. 51 W.	5.9	7.2	3.1	.....	.44

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Sept. 1	29.172	29.270	29.340	29.261	60	54	54	62	59	59	60.0	65	56	.491	.351	.351	.398
2	29.453	29.358	29.345	29.385	48	60	53	50	71	57	59.3	71	44	.309	.371	.350	.343
3	29.356	29.302	29.296	29.318	61	67	61	64	77	64	68.3	77	55	.497	.527	.497	.507
4	29.445	29.378	29.380	29.401	55	66	55	57	71	59	62.3	72	59	.477	.572	.380	.453
5	29.332	29.274	29.166	29.257	59	71	63	62	80	68	70.0	80	56	.460	.637	.509	.535
6	29.215	29.212	29.414	29.280	67	71	56	73	77	61	73.0	77	60	.595	.678	.393	.555
7	29.593	29.613	29.665	29.624	51	61	51	54	69	57	60.0	71	44	.335	.430	.295	.353
8	29.680	29.505	29.486	29.557	53	68	62	59	76	68	67.7	77	43	.323	.577	.476	.458
9	29.438	29.290	29.341	29.356	62	70	67	67	78	70	71.7	79	63	.489	.625	.623	.579
10	29.408	29.430	29.461	29.432	50	53	47	52	59	51	54.0	69	48	.334	.323	.270	.309
11	29.532	29.474	29.364	29.457	41	57	56	43	65	61	56.3	67	38	.231	.350	.396	.326
12	29.332	29.305	29.244	29.294	55	62	59	62	72	65	66.3	72	53	.340	.422	.430	.397
13	29.191	29.161	29.267	29.213	59	64	54	66	66	56	62.7	74	54	.497	.589	.391	.456
14	29.603	29.617	29.612	29.611	45	56	44	50	60	48	52.7	60	44	.234	.396	.236	.289
15	29.600	29.553	29.522	29.558	45	64	57	59	73	62	61.7	75	43	.247	.476	.399	.374
16	29.518	29.483	29.478	29.493	64	67	68	67	69	71	69.0	71	59	.556	.635	.644	.612
17	29.591	29.580	29.545	29.572	68	71	69	70	74	72	72.0	76	67	.658	.718	.668	.681
18	29.548	29.478	29.458	29.495	70	71	69	75	75	71	73.7	77	70	.666	.679	.682	.676
19	29.566	29.465	29.423	29.485	63	72	66	64	76	69	69.7	76	63	.562	.731	.599	.631
20	29.363	29.270	29.500	29.378	69	72	56	73	78	59	70.0	78	58	.655	.704	.409	.589
21	29.605	29.554	29.528	29.560	52	60	55	53	65	58	58.7	66	50	.375	.451	.393	.406
22	29.484	29.413	29.459	29.452	57	60	58	61	69	63	64.3	69	50	.412	.398	.416	.409
23	29.736	29.760	29.641	29.712	45	50	42	49	62	47	52.7	64	47	.247	.202	.208	.217
24	29.724	29.617	29.456	29.599	42	51	57	46	60	64	56.7	72	37	.215	.255	.373	.281
25	29.261	29.369	29.491	29.374	60	54	47	66	63	51	53.3	67	51	.433	.293	.270	.335
26	29.608	29.577	29.494	29.560	46	50	41	48	56	42	48.7	57	42	.284	.282	.244	.270
27	29.494	29.392	29.330	29.405	43	54	52	46	62	55	54.3	62	34	.238	.312	.349	.300
28	29.333	29.261	29.209	29.268	50	66	57	53	70	63	62.0	70	33	.321	.586	.399	.435
29	29.108	29.243	29.326	29.226	59	49	44	64	50	49	54.3	68	48	.433	.315	.223	.330
30	29.552	29.561	29.510	29.541	35	41	34	39	47	36	40.7	50	36	.152	.179	.170	.167
Means....	29.461	29.425	29.425	29.437	54.5	61.1	55.1	58.4	67.6	59.2	61.7	80	33	.397	.469	.400	.422
Oct. 1	29.480	29.340	29.295	29.342	35	52	50	36	59	53	49.3	60	31	.191	.296	.291	.259
2	29.046	28.985	29.103	29.045	51	59	52	61	65	58	61.3	66	52	.242	.430	.309	.394
3	29.298	29.272	29.337	29.302	46	53	38	48	58	41	49.0	58	40	.284	.393	.199	.292
4	29.435	29.380	29.312	29.376	36	53	40	38	59	43	46.7	62	32	.186	.323	.208	.239
5	29.026	29.169	29.369	29.188	55	51	41	57	52	44	51.0	58	44	.407	.361	.218	.329
6	29.649	29.678	29.702	29.676	39	44	41	41	52	43	48.0	52	40	.173	.183	.231	.196
7	29.845	29.837	29.790	29.824	34	44	33	38	52	36	42.0	52	33	.144	.183	.149	.158
8	29.780	29.680	29.496	29.635	33	49	41	36	59	45	46.7	60	30	.149	.216	.205	.190
9	29.319	29.138	29.046	29.168	41	56	53	44	60	57	53.7	60	41	.212	.396	.350	.321
10	28.901	28.831	28.864	28.865	52	55	49	55	59	50	54.7	60	50	.349	.380	.335	.355
11	28.967	28.981	29.073	29.007	48	54	49	49	59	51	53.0	54	48	.322	.351	.321	.331
12	29.149	29.198	29.250	29.199	47	47	54	48	48	55	51.3	52	44	.310	.310	.484	.341
13	29.384	29.357	29.376	29.372	45	52	47	46	56	49	50.3	56	38	.286	.335	.297	.306
14	29.417	29.380	29.317	29.371	40	53	53	41	59	56	52.0	59	38	.215	.383	.363	.307
15	29.333	29.357	29.416	29.369	50	53	47	54	60	49	51.0	61	49	.308	.310	.297	.305
16	29.524	29.462	29.432	29.473	41	59	56	42	62	62	55.3	63	38	.244	.460	.369	.358
17	29.437	29.271	29.211	29.306	57	62	64	60	70	66	65.3	70	60	.426	.448	.388	.421
18	29.294	29.271	29.290	29.285	58	60	57	61	66	59	62.0	67	59	.443	.438	.439	.440
19	29.409	29.376	29.437	29.407	60	61	58	63	68	60	63.7	68	56	.478	.443	.456	.459
20	29.537	29.518	29.482	29.512	57	63	57	60	75	62	65.7	77	54	.426	.415	.389	.413
21	29.486	29.353	29.326	29.388	57	68	56	64	73	64	67.0	73	59	.373	.618	.343	.445
22	29.453	29.503	29.579	29.512	48	46	41	50	54	44	49.3	65	43	.309	.206	.218	.244
23	29.755	29.776	29.772	29.768	37	44	37	38	49	39	42.0	51	37	.207	.223	.194	.208
24	29.866	29.825	29.785	29.825	29	46	36	30	53	38	40.3	53	29	.149	.219	.186	.151
25	29.818	29.738	29.699	29.752	32	46	40	33	52	44	43.0	58	31	.168	.232	.195	.198
26	29.721	29.680	29.656	29.652	31	49	42	32	59	45	45.3	58	31	.164	.216	.226	.202
27	29.730	29.672	29.636	29.679	34	50	42	36	62	45	47.7	62	32	.170	.208	.226	.201
28	29.614	29.610	29.488	29.581	42	50	47	46	55	48	49.7	56	40	.215	.295	.310	.273
29	29.488	29.323	29.281	29.364	46	51	47	48	54	51	51.0	56	46	.284	.315	.270	.290
30	29.287	29.197	29.162	29.215	40	51	46	41	56	47	48.0	57	40	.215	.308	.297	.273
31	29.304	29.351	29.446	29.367	44	47	42	46	51	45	47.3	53	45	.262	.270	.238	.257
Means....	29.456	29.418	29.411	29.428	45.0	52.6	47.0	37.0	58.6	50.0	48.5	77	29	.269	.396	.293	.297

he northern and northwestern lakes at Buffalo, New York:

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.884	.703	.703	.763	NW..	NW..	SW...	4	12	2	5.3	N. 53 W.	10	10	1	.....	.20
.856	.490	.752	.699	SE....	SE....	NE ...	2	2	4	1.9	East ...	0	9	0	.....	.....
.833	.569	.833	.745	S	W	W	12	25	12	13.0	S. 72 W.	9	6	10	.....	.....
.874	.754	.761	.796	NE ...	SW...	NE ...	2	2	2	0.7	N. 45 E.	0	2	0	.....	.76
.828	.623	.743	.731	NE ...	W.byS	SE....	2	4	2	0.7	S. 72 W.	0	1	0	.....	.....
.758	.731	.713	.734	SW...	SW...	NE ..	12	12	2	7.3	S. 45 W.	10	9	8	.....	.....
.802	.607	.634	.681	NE ...	NE ...	NE ...	2	4	2	2.7	N. 45 E.	1	3	0	.....	.....
.647	.644	.695	.662	NE ...	W.byN	E	4	4	12	3.7	N. 71 E	3	3	0	.....	.....
.740	.653	.848	.747	W.SW	W.SW	NW ..	12	25	4	12.7	S. 79 W.	10	9	10	.....	.....
.861	.647	.722	.743	W.byN	NW ..	NE ...	4	12	2	5.0	N. 47 W.	10	9	0	.....	.32
.833	.582	.765	.727	SE....	SW...	W	2	12	2	4.3	S. 44 W.	0	1	0	.....	.....
.612	.539	.680	.610	SW...	SW...	SW...	12	25	4	12.7	S. 45 W.	0	6	10	.....	.....
.636	.891	.872	.800	SWbyS	NWb.W	W	12	4	2	4.7	S. 59 W.	10	10	10	.....	.....
.646	.765	.704	.705	NE ...	NE ...	NE ...	4	12	4	6.7	N. 45 E.	0	1	0	.....	.28
.710	.588	.718	.672	E	S	E	2	2	12	5.0	S. 81 E	7	1	0	.....	.....
.841	.896	.850	.862	SW...	SW...	SW...	12	4	2	6.0	S. 45 W.	10	10	1	.....	.....
.898	.856	.832	.869	SW...	SW...	SE....	12	12	2	8.0	S. 40 W.	9	0	0	.....	.28
.768	.810	.899	.826	SW...	SW..	NW ..	2	12	2	4.7	S. 53 W.	6	2	10	.....	.....
.943	.815	.846	.868	NE ...	SW...	SE....	2	2	2	0.7	S. 45 E.	10	8	0	.....	.24
.807	.734	.819	.787	SW...	SW...	NW ..	12	12	2	8.0	S. 50 W.	1	5	0	.....	.....
.932	.731	.816	.826	NW..	W.SW	NE ...	2	4	2	1.3	N.71 W.	10	6	0	.....	.....
.769	.564	.723	.685	SW...	W.SW	NW ..	4	45	2	16.3	S. 68 W.	8	10	0	.....	.....
.710	.364	.624	.566	NE ...	NE ...	NE ...	4	4	4	4.0	N. 45 E	8	0	0	.....	.....
.691	.493	.625	.603	SW...	SW...	SW...	2	12	25	13.0	S. 45 W.	0	6	0	.....	.....
.685	.519	.722	.642	W	NW ..	NW ..	12	25	12	15.3	N. 56 W	10	10	0	.....	.....
.850	.627	.914	.797	NE ...	NE ...	NE ...	4	4	2	3.3	N. 45 E	10	9	0	.....	.....
.767	.561	.805	.711	SE....	W.SW	E	2	4	2	1.0	S. 11 W.	0	0	0	.....	.....
.798	.799	.718	.772	S	W.SW	W.SW	4	12	4	6.0	S. 56 W.	0	10	0	.....	.....
.727	.927	.638	.764	SW...	NE ...	NE ...	4	12	4	4.0	N. 45 E	0	10	10	.....	.....
.336	.554	.802	.664	NE ...	NW ..	NE ...	2	4	2	2.7	N. 10 E	10	6	0	.....	.06
.778	.668	.760	.735	.....	.....	.....	....	....	....	3.2	S. 71 W.	5.4	5.7	2.3	.....	2.14
.900	.592	.798	.763	SE....	W.SW	S	2	12	2	4.3	S. 49 W.	9	1	0	.....	.....
.452	.680	.641	.591	SW...	W.SW	NW ..	12	25	12	14.0	S. 77 W.	8	10	10	.....	.....
.850	.816	.738	.801	NE ...	NE ...	NE ...	2	4	2	2.7	N. 45 E	10	7	3	.....	.....
.811	.647	.750	.736	NE byE	NE ...	S	2	4	4	1.3	S. 83 E .	0	6	9	.....	.....
.874	.930	.756	.853	SW...	NW ..	NW ..	12	2	12	6.3	N. 85 W.	10	10	10	.....	.50
.597	.472	.833	.634	NW ..	NW ..	NW ..	4	12	2	6.0	N. 45 W.	0	6	0	.....	.16
.628	.472	.705	.602	N.....	S	NE ...	2	2	2	0.7	N. 45 E	0	6	0	.....	.....
.705	.432	.684	.607	E	N. SW	E.SE..	2	2	4	1.3	S. 55 E .	2	1	0	.....	.....
.756	.765	.752	.758	E	W.SW	W.SW	2	4	45	15.7	N. 67 W.	10	10	10	.....	.....
.805	.761	.927	.831	SW...	SW...	SW...	25	25	2	17.3	S. 45 W.	10	10	10	.....	.26
.926	.703	.859	.829	NE ...	SE....	S	2	2	2	1.0	S. 46 E.	10	10	10	.....	.58
.925	.925	.934	.928	S	NE ...	NE ...	2	4	2	1.7	N. 64 E.	10	10	10	.....	.18
.921	.747	.853	.840	W	W.byS	NW ..	2	12	4	5.3	N. 86 W.	10	10	0	.....	.20
.912	.647	.809	.789	SW...	SW...	SW...	2	12	12	8.7	S. 45 W.	0	4	0	.....	.....
.738	.599	.853	.730	W	NW ..	NE ...	2	2	2	1.0	N.41 W.	10	9	0	.....	.....
.914	.828	.665	.802	SE....	SW...	SW...	2	2	12	4.7	S. 37 W.	0	0	0	.....	.....
.822	.613	.891	.775	W	W	W	4	12	25	13.7	West . .	9	9	9	.....	.....
.825	.685	.878	.796	W	SW...	NW ..	2	4	2	2.3	S. 79 W.	0	0	0	.....	.....
.831	.647	.880	.786	SW...	SW...	SW...	4	4	2	3.3	S. 45 W.	10	9	0	.....	.....
.832	.479	.718	.673	S	S	S	2	2	2	2.0	South .	0	0	0	.....	.....
.625	.761	.575	.654	SW...	SW...	SW...	4	2	12	6.0	S. 45 W.	4	8	10	.....	.06
.856	.493	.756	.702	NW ..	NW ..	NW ..	2	4	2	2.7	N. 45 W.	10	10	0	.....	.04
.905	.638	.816	.786	NW ..	NW ..	SE....	2	4	2	1.3	N. 45 W.	3	8	0	.....	.....
.890	.544	.811	.748	NE ...	NE ...	NE ...	2	2	2	2.0	N. 45 E.	0	0	0	.....	.....
.893	.598	.677	.723	SE	NE ...	NE ...	2	2	2	1.7	N. 74 E	0	0	0	.....	.....
.896	.432	.762	.697	NE ...	NE ...	NE ...	2	2	2	2.0	N. 45 E	0	0	0	.....	.....
.802	.364	.762	.643	NE ...	NE ...	NE ...	2	2	4	2.7	N. 45 E	3	10	0	.....	.....
.691	.681	.925	.766	NE ...	NE ...	NE ...	2	4	4	3.3	N. 45 E	10	10	10	.....	.10
.850	.802	.722	.791	NE ...	NE ...	NE ...	12	12	2	8.7	N. 45 E.	10	10	10	.....	.....
.912	.687	.923	.841	SW...	SW...	SW...	2	4	2	2.7	S. 45 W.	10	1	0	.....	.....
.843	.722	.762	.776	NW ..	NW ..	NW ..	4	12	4	6.7	N.45 W.	10	10	10	.....	.....
.489	.650	.787	.642	.....	.....	.....	....	....	....	2.6	S. 78 W.	5.7	6.3	3.9	.....	2.08

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Nov. 1	29.396	29.167	29.013	29.192	45	49	50	49	56	58	54.3	58	41	.247	.255	.255	.252
2	28.939	29.001	29.186	29.042	53	50	40	56	59	45	53.3	62	43	.363	.242	.183	.262
3	29.112	28.801	28.670	28.861	38	54	55	43	59	56	52.7	60	39	.164	.351	.430	.312
4	29.147	29.301	29.523	29.324	39	43	33	41	47	35	41.0	62	34	.212	.225	.169	.209
5	29.555	29.562	29.509	29.542	29	38	36	34	39	41	39.0	47	32	.103	.216	.108	.142
6	29.565	29.600	29.603	29.589	30	37	30	34	40	31	35.0	44	31	.121	.181	.155	.152
7	29.455	29.311	29.252	29.339	32	45	39	34	51	43	42.7	53	30	.155	.220	.186	.187
8	29.163	29.089	29.182	29.145	44	58	56	50	63	62	58.3	63	39	.209	.416	.369	.331
9	29.028	29.167	29.235	29.143	55	51	46	60	56	53	56.3	65	52	.367	.308	.219	.298
10	29.323	29.307	29.316	29.315	50	52	40	54	56	49	53.0	56	45	.308	.335	.130	.258
11	29.344	29.335	29.363	29.347	35	34	30	42	34	35	37.0	50	43	.113	.196	.139	.116
12	29.343	29.335	29.368	29.349	30	33	32	31	34	33	32.7	37	29	.155	.175	.168	.166
13	29.246	29.238	29.251	29.245	29	35	30	30	37	32	33.0	38	28	.149	.178	.144	.157
14	28.930	29.135	29.328	29.131	37	37	29	40	42	33	38.3	47	30	.181	.155	.114	.150
15	29.557	29.545	29.320	29.474	25	32	32	26	34	36	32.0	37	24	.123	.155	.129	.136
16	29.273	29.250	29.393	29.305	33	32	29	35	36	31	34.0	45	31	.162	.129	.137	.143
17	29.211	29.138	29.203	29.184	30	34	29	32	37	31	33.3	39	30	.144	.157	.137	.146
18	29.393	29.375	29.422	29.397	15	22	21	16	23	24	21.0	33	16	.074	.107	.079	.087
19	29.527	29.533	29.496	29.519	21	30	27	22	31	30	27.7	33	16	.101	.153	.113	.123
20	29.342	29.281	29.404	29.342	34	43	39	39	47	42	42.7	47	29	.131	.225	.199	.185
21	29.493	29.444	29.421	29.453	30	41	30	31	45	32	36.0	46	31	.155	.205	.141	.168
22	29.418	29.347	29.356	29.374	43	49	44	48	56	49	51.0	56	30	.212	.255	.223	.230
23	29.426	29.395	29.424	29.415	46	49	44	49	53	46	49.3	54	46	.271	.293	.269	.276
24	29.424	29.312	29.310	29.349	44	52	51	46	58	55	53.0	61	39	.262	.309	.321	.297
25	29.305	29.150	29.089	29.181	49	52	50	53	59	52	54.7	60	51	.295	.296	.334	.308
26	29.290	29.416	29.545	29.417	36	39	36	40	45	38	41.0	52	37	.160	.160	.186	.169
27	29.583	29.434	29.324	29.447	34	40	39	35	42	42	39.7	43	35	.183	.221	.199	.201
28	29.375	29.362	29.357	29.365	37	41	38	38	43	41	40.7	44	36	.207	.231	.190	.209
29	29.097	28.688	28.588	28.791	39	44	36	41	45	37	41.0	46	36	.212	.275	.159	.229
30	29.093	29.270	29.544	29.302	15	16	11	16	17	12	15.0	37	10	.074	.078	.061	.071
Means ...	29.312	29.280	29.300	29.297	35.9	41.1	36.7	38.8	44.8	40.2	41.3	65	10	.187	.223	.189	.200
Dec. 1	29.603	29.547	29.466	29.539	15	19	13	16	22	15	17.7	26	13	.074	.069	.056	.066
2	29.341	29.330	29.390	29.354	27	33	33	28	36	36	33.3	37	24	.136	.149	.149	.145
3	29.443	29.213	29.146	29.267	27	33	32	31	35	34	33.3	37	27	.101	.162	.155	.139
4	29.242	29.117	29.035	29.140	13	21	18	14	22	19	18.3	30	14	.067	.101	.087	.085
5	29.074	29.204	29.244	29.174	22	24	25	23	27	27	25.7	50	18	.107	.113	.112	.111
6	28.997	28.632	28.851	28.827	30	39	35	35	41	36	37.3	46	20	.109	.212	.191	.171
7	29.041	29.124	29.351	29.172	24	26	11	25	27	13	21.7	36	12	.117	.129	.049	.098
8	29.416	29.385	29.408	29.403	14	21	16	15	23	18	18.7	23	9	.071	.090	.067	.076
9	29.567	29.448	29.234	29.416	7	17	26	7	18	27	17.3	27	6	.059	.083	.129	.104
10	29.169	29.217	29.235	29.214	24	21	13	25	22	15	20.7	30	14	.117	.101	.056	.091
11	29.283	29.275	29.358	29.305	15	21	17	16	23	18	15.7	27	13	.074	.090	.083	.082
12	29.408	29.455	29.428	29.430	2	3	2	3	4	3	03.3	18	2	.056	.008	.036	.033
13	29.572	29.552	29.562	29.562	4	7	4	5	9	5	06.3	9	2	.041	.037	.041	.040
14	29.530	29.398	29.344	29.424	1	12	11	2	14	12	09.3	17	1	.034	.052	.061	.049
15	29.333	29.285	29.222	29.280	15	20	22	16	23	24	21.0	25	11	.074	.074	.095	.081
16	29.273	29.219	29.182	29.225	19	22	22	20	25	24	23.0	25	20	.092	.084	.084	.087
17	28.994	28.919	29.131	29.015	21	28	27	23	29	28	26.7	29	22	.090	.142	.136	.123
18	29.433	29.518	29.668	29.550	15	17	13	16	18	14	16.0	28	13	.074	.083	.067	.075
19	29.866	29.847	29.739	29.817	10	15	9	11	18	10	13.0	17	10	.057	.052	.054	.054
20	29.354	29.387	29.581	29.441	26	33	31	27	35	32	31.3	25	10	.129	.163	.162	.151
21	.....	29.513	29.356	29.450	....	28	29	....	31	30	30.3	33	26	.....	.119	.149	.089
22	28.865	28.908	28.998	28.924	44	35	32	46	37	33	38.7	49	29	.262	.178	.168	.203
23	29.251	29.571	29.639	29.487	27	27	23	28	28	25	27.0	36	25	.136	.136	.100	.124
24	29.469	29.262	29.390	29.374	26	34	33	29	39	36	34.7	39	24	.106	.131	.149	.129
25	29.383	29.112	28.819	29.105	34	45	50	35	47	52	44.7	52	31	.183	.273	.334	.263
26	29.290	29.395	29.515	29.400	35	35	32	36	38	34	36.0	53	33	.191	.165	.155	.170
27	28.947	28.736	29.022	28.902	44	52	40	45	53	43	47.0	54	33	.275	.375	.208	.286
28	29.331	29.388	29.368	29.359	30	31	31	32	33	33	32.7	44	30	.144	.151	.151	.149
29	29.545	29.614	29.693	29.618	22	21	17	23	23	19	21.7	31	19	.107	.090	.071	.089
30	29.788	29.878	29.861	29.842	17	17	12	18	18	13	16.3	22	11	.083	.083	.063	.076
31	29.824	29.681	29.401	29.635	8	24	26	8	28	28	21.3	29	5	.062	.083	.117	.087
Means ...	29.354	29.329	29.344	29.344	20.6	25.2	22.7	21.9	27.3	24.4	24.4	54	1	.110	.127	.118	.118

the northern and northwestern lakes at Buffalo, New York.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation=1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.710	.569	.529	.603	SW..	SW..	SW..	12	35	45	30.7	S. 45 W.	10	10	2	.....	.....
.809	.484	.607	.633	W. SW	W. SW	N.....	45	45	2	29.7	S. 68 W.	3	10	10	.....	.....
.587	.703	.935	.742	NE...	SW..	S.....	2	2	35	11.7	South..	10	10	10	.....	.....
.824	.698	.797	.773	W....	W....	W....	12	12	4	9.3	West...	10	9	0	.....	.38
.524	.907	.372	.601	W. by N	W. SW	W. SW	12	75	35	4.0	S. 71 W.	10	10	2	.....	.....
.617	.732	.893	.747	W....	W....	W....	2	4	4	3.3	West...	10	10	10	.....	.....
.792	.590	.669	.684	W....	S. SW.	SE....	2	2	12	4.0	S. 29 E.	10	10	0	.....	.....
.581	.723	.665	.656	S.....	S.....	S.....	4	25	25	18.0	South..	0	9	10	.....	.....
.708	.687	.544	.646	W....	W....	W....	4	12	4	6.7	West...	10	9	0	.....	.....
.738	.747	.373	.619	SSW.	W....	NW..	2	4	12	5.0	N. 64 W.	8	10	0	.....	.....
.420	1.000	.557	.659	W....	E.....	NW..	2	2	2	0.7	N. 45 W.	10	10	0	.....	.....
.893	.895	.893	.894	NW..	NW..	NW..	2	4	12	6.0	N. 45 W.	9	10	9	.....	.02
.890	.807	.794	.830	NW..	NW..	NE...	2	4	2	2.0	N. 28 W.	10	9	10	.....	.....
.732	.577	.606	.638	W. SW	W. NW	NW..	4	4	4	3.7	N. 75 W.	10	10	10	.....	.02
.876	.792	.610	.759	W....	W....	W....	2	12	12	8.7	West...	10	10	10	.....	.....
.797	.610	.788	.732	NW..	NW..	NW..	12	12	4	9.3	N. 45 W.	10	10	6	.....	.....
.794	.712	.788	.765	W....	W....	W....	4	12	4	6.7	West...	10	10	10	.....	.....
.829	.864	.610	.768	NW..	NW.	NW..	4	4	4	4.0	N. 45 W.	10	5	10	.....	.....
.860	.893	.675	.809	N. NW.	W....	NW..	2	4	2	2.3	N. 63 W.	10	8	10	.....	.....
.547	.698	.744	.663	S.....	W SW	NW..	12	25	2	10.7	S. 50 W.	10	10	10	.....	.....
.893	.684	.794	.790	NE...	SW..	NE...	2	2	2	0.7	N. 45 E.	10	10	0	.....	.....
.631	.569	.638	.613	SE....	S. SE..	SW..	4	4	2	2.7	S. 21 E	10	10	10	.....	.....
.781	.733	.843	.786	S.....	S.....	S.....	2	2	2	2.0	South..	10	10	10	.....	.....
.843	.641	.743	.742	S.....	S.....	S.....	2	4	4	3.3	South..	10	10	10	.....	.....
.733	.592	.861	.729	SW..	SW..	SW..	4	4	12	6.7	S. 45 W.	10	10	10	.....	.14
.645	.533	.811	.663	NW..	NW...	NW..	12	2	4	6.0	N. 45 W.	10	10	10	.....	.26
.898	.829	.744	.824	E.....	S. SW.	SW..	2	2	2	1.0	S. 6 W..	10	10	10	.....	.....
.905	.893	.738	.825	NE...	NE...	NE...	2	4	2	2.7	N. 45 E.	10	7	10	.....	.06
.824	.920	.903	.882	SE....	SE....	NW...	4	4	4	1.3	S. 45 E.	10	10	10	.....	.....
.829	.834	.804	.822	NW..	NW..	NW...	12	12	4	9.3	N. 45 W.	10	6	8	.....	.42
.750	.728	.711	.730	.....	.....	.....	....	....	....	6.4	S. 68 W.	9.3	9.4	7.2	.....	1.30
.829	.584	.648	.687	SE....	S.....	SW..	2	4	12	5.0	S. 28 W.	10	10	10	.....	.....
.883	.705	.705	.764	S.....	W. SW	N. NW.	12	12	12	5.3	S. 70 W.	10	10	10	.....	.08
.582	.797	.792	.724	NW..	NW..	NW...	4	12	12	9.3	N. 45 W.	10	10	10	.....	.08
.816	.860	.845	.840	NE...	NW..	NW...	2	2	4	2.0	N. 28 W.	10	10	8	.....	.02
.864	.675	.761	.767	W....	W....	W....	2	4	4	3.3	West...	9	7	10	.....	.....
.537	.824	.900	.754	S.....	SW..	NW...	4	25	35	14.3	N. 85 W.	10	10	10	.....	.....
.872	.880	.623	.758	NW..	NW..	NW...	12	25	25	20.7	N. 45 W.	10	10	0	.....	.....
.823	.730	.682	.745	W....	W....	W....	12	4	12	9.3	West...	3	4	9	.....	.....
1.000	.840	.880	.873	NE...	SE....	W....	2	4	25	7.3	S. 85 W.	7	10	10	.....	.....
.472	.860	.648	.793	NW..	NW..	NW...	12	4	2	6.0	N. 45 W.	10	9	10	.....	.36
.829	.730	.840	.800	SW..	NE...	NE...	2	2	2	0.7	N. 45 E.	10	10	10	.....	.....
.730	.740	.730	.733	NE...	NE...	NE...	4	12	12	9.3	N. 45 E.	10	10	10	.....	.....
.750	.568	.750	.689	NE...	NE...	NE...	4	12	4	6.7	N. 45 E.	10	7	3	.....	.....
.718	.635	.804	.719	NE...	NE...	NE...	2	4	2	2.7	N. 45 E.	10	10	10	.....	.....
.829	.598	.738	.722	NE...	NE...	NW...	2	4	2	2.0	N. 28 E.	10	7	10	.....	.....
.850	.622	.622	.698	W....	W. NW	E. SE.	2	2	2	0.7	West...	10	10	10	.....	.....
.730	.887	.883	.833	E.....	W....	NW...	2	2	2	0.7	N. 45 W.	10	10	10	.....	.....
.829	.840	.816	.828	NE...	N.....	NW...	2	4	4	3.0	N. 9 W.	10	10	10	.....	.....
.797	.525	.791	.704	NE...	NE...	NE...	2	2	2	2.0	N. 45 E.	10	1	0	.....	.....
.880	.797	.896	.858	W....	W....	W....	12	12	12	12.0	West...	10	10	10	.....	.04
.....	.685	.890	.788	.....	W....	SE.....	....	12	12	3.0	S. 23 W.	....	10	10	.....	.....
.843	.807	.893	.848	SW..	SW..	SW..	12	45	45	34.0	S. 45 W.	10	10	0	.....	.66
.883	.883	.746	.837	W. by S	W....	NW...	12	12	2	8.3	S. 89 W.	10	10	10	.....	.....
.665	.547	.705	.639	SW..	SW..	SW..	4	25	2	10.7	S. 45 W.	10	10	0	.....	.....
.898	.847	.861	.869	NE...	SW..	SW..	4	4	25	8.3	S. 45 W.	10	10	10	.....	.....
.900	.719	.792	.804	W. SW	W. SW	NE...	25	12	2	11.7	S. 69 E.	10	10	10	.....	.22
.920	.932	.750	.867	W. SW	SW..	NW...	2	25	2	9.0	S. 49 W.	10	10	0	.....	.58
.794	.800	.800	.798	NW..	NW..	W. SW	2	4	12	5.0	S. 89 W.	10	10	2	.....	.38
.864	.730	.692	.762	NW..	NW..	NW...	12	12	4	9.3	N. 45 W.	10	10	0	.....	.....
.840	.840	.810	.830	W. NW	NW..	S.....	2	12	4	4.0	N. 64 W.	10	10	0	.....	.....
1.000	.543	.768	.770	E....	E.....	E.....	2	2	12	5.3	East ...	10	10	10	.....	.....
.817	.743	.776	.777	.....	.....	.....	....	....	....	3.8	S. 89 W.	9.6	9.5	7.4	.....	2.42

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Jan. 1	29.969	30.063	30.018	30.017	19	25	18	21	28	21	23.3	28	18	.089	.100	.065	.085
2	30.120	30.013	29.934	30.022	13	13	14	15	21	17	17.7	24	13	.056	.080	.048	.061
3	30.009	29.937	29.818	29.921	13	27	22	16	30	25	23.7	30	12	.044	.113	.084	.080
4	29.939	29.843	29.747	29.843	25	35	27	28	37	30	31.7	37	21	.100	.178	.113	.130
5	29.528	29.425	29.315	29.423	24	30	27	26	32	30	29.3	34	24	.106	.144	.113	.121
6	29.541	29.488	29.590	29.540	25	30	23	28	32	25	28.3	32	23	.100	.144	.100	.115
7	29.725	29.798	29.685	29.739	20	16	17	28	23	18	23.0	30	16	.017	.010	.063	.030
8	29.745	29.608	29.505	29.619	17	20	16	20	23	19	20.7	25	16	.060	.074	.056	.063
9	29.421	29.458	29.221	29.367	19	27	17	22	30	20	24.0	30	17	.069	.113	.069	.081
10	29.160	29.155	29.285	29.200	22	25	20	24	28	22	24.7	29	20	.095	.100	.085	.093
11	29.581	29.635	29.648	29.621	16	22	18	18	25	20	21.0	26	16	.067	.084	.076	.076
12	29.998	29.926	30.003	29.976	13	14	11	15	16	14	15.0	24	10	.056	.059	.037	.051
13	29.773	29.570	29.638	29.600	13	14	12	15	17	14	15.3	17	11	.056	.048	.052	.052
14	29.768	29.725	29.588	29.694	15	16	12	17	19	14	16.7	20	12	.052	.056	.052	.053
15	29.745	29.903	29.899	29.849	10	13	11	12	15	13	13.3	18	10	.046	.056	.049	.150
16	29.806	29.781	29.445	29.677	13	22	17	15	25	20	20.0	25	12	.056	.084	.069	.087
17	29.490	29.608	29.973	29.690	20	14	8	22	17	10	16.3	22	8	.065	.048	.040	.038
18	29.829	29.685	29.330	29.615	6	9	6	8	12	9	09.7	20	7	.034	.031	.037	.034
19	29.645	29.633	29.568	29.615	8	15	9	10	18	11	13.0	18	8	.040	.052	.043	.045
20	29.720	29.573	29.418	29.570	10	20	14	12	22	16	16.7	23	10	.046	.085	.059	.063
21	29.333	29.204	29.395	29.311	17	22	18	20	25	20	21.7	25	17	.060	.084	.076	.073
22	29.588	29.665	29.736	29.663	16	20	18	18	23	20	20.3	23	16	.067	.074	.076	.072
23	29.714	29.836	29.943	29.831	20	25	19	23	28	21	24.0	26	19	.074	.100	.080	.085
24	30.069	30.046	30.096	30.070	24	27	21	26	30	24	26.7	30	21	.106	.113	.079	.099
25	30.008	29.666	29.272	29.649	22	23	18	25	26	21	24.0	27	17	.084	.089	.065	.079
26	29.187	29.169	29.208	29.188	24	25	19	27	28	21	25.3	30	19	.095	.100	.086	.093
27	29.332	29.421	29.765	29.506	16	18	15	19	21	17	19.0	24	14	.056	.065	.063	.061
28	29.728	29.756	29.665	29.716	15	19	15	18	22	17	19.0	22	15	.052	.069	.063	.061
29	29.809	29.616	29.961	29.795	5	9	7	7	12	9	09.3	20	5	.032	.031	.037	.033
30	30.109	30.211	30.009	30.110	3	20	8	5	23	10	12.7	23	3	.027	.074	.040	.047
31	29.884	29.723	29.638	29.748	18	32	27	21	35	30	28.7	36	18	.065	.142	.113	.107
Means....	29.718	29.682	29.656	29.685	16.2	21.1	13.1	18.7	24.0	18.7	20.5	37	3	.064	.084	.067	.072
Feb. 1	29.551	29.641	29.722	29.640	38	32	27	41	35	30	35.3	43	27	.190	.142	.113	.148
2	29.621	29.326	29.063	29.337	24	27	22	27	30	24	27.0	35	22	.095	.113	.095	.101
3	29.023	29.331	29.228	29.194	30	30	23	33	32	26	30.3	33	23	.132	.144	.089	.122
4	29.331	29.515	29.301	29.382	24	34	27	27	37	30	31.3	38	24	.095	.157	.113	.122
5	29.491	29.585	29.756	29.611	31	25	22	34	28	24	32.0	34	22	.139	.100	.095	.111
6	29.909	29.969	30.063	29.980	23	31	25	26	34	28	29.3	35	23	.089	.139	.100	.109
7	30.117	30.056	29.903	30.025	23	40	34	26	43	36	35.0	44	23	.089	.208	.170	.156
8	29.825	29.621	29.516	29.654	24	40	35	28	42	37	35.0	43	24	.106	.221	.178	.168
9	29.448	29.323	29.458	29.410	38	24	17	40	27	20	29.0	40	17	.203	.095	.060	.119
10	29.693	29.697	29.450	29.613	8	6	4	10	8	6	08.0	20	4	.040	.034	.030	.035
11	30.555	30.165	30.122	30.281	5	27	22	8	30	24	20.7	30	5	.021	.113	.095	.076
12	30.205	30.234	30.139	30.193	34	37	27	36	40	30	35.3	40	27	.170	.181	.113	.115
13	30.065	29.869	29.783	29.906	32	40	37	35	43	40	39.3	43	32	.142	.208	.181	.117
14	29.837	29.641	30.005	29.828	33	34	27	36	37	30	34.3	40	27	.149	.157	.113	.140
15	30.246	30.121	30.030	30.132	19	27	19	22	29	21	24.0	30	19	.069	.124	.080	.091
16	29.626	29.531	29.608	29.588	35	45	38	38	47	40	41.7	47	34	.165	.273	.203	.214
17	29.738	29.923	29.969	29.877	33	36	31	35	39	34	36.3	45	31	.162	.173	.139	.158
18	29.862	29.746	29.721	29.776	25	34	27	27	36	30	31.0	36	24	.112	.170	.113	.132
19	30.010	30.055	29.914	29.993	26	23	18	29	26	20	25.0	30	18	.106	.089	.076	.090
20	29.870	29.797	29.929	29.865	19	25	19	21	28	20	23.0	28	18	.080	.100	.092	.091
21	29.818	29.531	29.652	29.667	23	25	19	26	28	21	25.0	29	18	.089	.100	.080	.090
22	29.862	29.855	30.049	29.922	24	22	17	26	25	19	23.0	27	17	.106	.084	.071	.087
23	29.664	29.481	29.184	29.443	20	37	32	23	40	35	32.7	40	20	.074	.181	.142	.132
24	29.464	29.496	29.775	29.578	30	31	21	32	34	24	30.0	35	21	.144	.139	.079	.121
25	29.962	29.859	29.979	29.933	19	24	18	21	26	20	22.3	27	18	.090	.106	.076	.087
26	29.915	30.047	30.159	30.040	21	32	22	24	35	25	28.0	35	21	.079	.142	.084	.102
27	30.230	30.149	30.127	30.169	25	33	26	27	35	28	30.0	36	25	.119	.162	.117	.130
28	29.845	29.817	29.802	29.821	30	40	32	32	43	35	36.7	43	30	.144	.209	.142	.165
Means....	29.814	29.764	29.765	29.781	25.6	30.7	24.6	28.1	33.5	27.0	29.5	47	4	.114	.145	.108	.122

e northern and northwestern lakes at Fort Niagara, New York.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
712	.655	.750	.706	W.	W.	W.	4	25	35	21.3	West.	8	5	7	.....	.....
648	.712	.509	.623	W.	SW.	SW.	12	25	35	23.0	S. 52 W.	5	6	8	.....	.....
492	.675	.622	.596	SW.	SW.	SW.	12	35	25	24.0	S. 45 W.	4	7	8	.....	.....
655	.807	.675	.712	S.	SW.	SW.	35	12	35	25.3	S. 26 W.	6	4	7	.....	.....
754	.794	.675	.741	W.	S.	W.	4	35	12	13.0	S. 25 W.	6	8	10	.....	.28
655	.794	.746	.732	W.	W.	W.	45	35	45	41.7	West.	10	7	10	.....	.....
110	.684	.840	.345	NW.	NW.	W.	45	60	25	41.7	N. 53 W.	7	10	7	.....	.....
556	.598	.541	.565	W.	W.	W.	25	12	4	13.7	West.	7	4	6	.....	.....
584	.675	.556	.605	SW.	SW.	SW.	2	2	2	2.0	S. 45 W.	10	7	8	.....	.....
738	.655	.721	.705	W.	W.	W.	4	12	4	6.7	West.	10	6	5	.....	.12
682	.622	.702	.669	W.	W.	W.	2	2	4	2.7	West.	5	4	6	.....	.....
648	.659	.457	.588	NW.	W.	W.	12	2	4	5.7	N. 60 W.	5	3	6	.....	.....
648	.509	.635	.597	NE.	NE.	N.	25	4	4	10.7	N. 40 E	6	4	7	.....	.....
525	.541	.645	.567	SW.	SW.	SW.	2	2	4	2.7	S. 45 W.	4	5	4	.....	.....
510	.648	.623	.627	N.	W.	W.	4	2	4	2.7	N. 60 W.	3	4	5	.....	.....
648	.622	.556	.609	S.	W.	W.	2	2	2	1.7	S. 67 W.	5	3	10	.....	.26
721	.549	.582	.604	NE.	W.	NW.	4	25	35	18.0	N. 59 W.	10	7	5	.....	.....
553	.418	.568	.513	N.	NW.	N.	35	25	35	29.7	N. 11 W.	5	4	6	.....	.....
592	.525	.596	.568	W.	W.	W.	12	4	2	6.0	West.	4	2	4	.....	.....
610	.721	.659	.663	S.	NE.	E.	2	4	2	1.7	N. 81 E.	3	5	6	.....	.40
556	.622	.702	.627	E.	W.	W.	4	2	4	0.7	West.	5	6	10	.....	.08
682	.598	.702	.661	W.	SW.	S.	2	2	2	1.7	S. 45 W.	4	3	5	.....	.....
598	.655	.712	.655	W.	W.	W.	2	4	2	2.7	West.	4	5	4	.....	.....
754	.675	.610	.680	W.	W.	W.	2	2	4	2.7	West.	4	4	6	.....	.....
822	.634	.570	.609	E.	E.	E.	2	4	12	6.0	East.	4	6	10	.....	.30
544	.655	.712	.670	S.	S.	S.	25	12	25	20.7	South.	4	3	5	.....	.....
541	.570	.671	.594	SW.	SW.	SW.	25	12	35	24.0	S. 45 W.	4	6	7	.....	.....
525	.584	.671	.593	S.	S.	W.	12	4	2	5.7	S. 7 W	6	4	5	.....	.....
538	.418	.568	.508	W.	SW.	W.	4	12	4	6.3	S. 63 W.	3	4	6	.....	.....
500	.598	.582	.560	S.	S.	S.	12	2	2	5.3	South.	4	3	4	.....	.....
570	.698	.675	.648	SW.	SW.	SW.	2	2	4	2.7	S. 45 W.	3	4	5	.....	.....
502	.611	.639	.617	.....	.....	.....	....	....	....	7.2	S. 78 W.	5.1	5.0	6.5	.....	1.57
738	.698	.675	.704	W.	W.	W.	4	12	4	6.7	West.	6	5	4	.....	.....
544	.675	.738	.686	W.	W.	NE.	2	12	25	6.0	N. 11 E.	3	7	6	.....	.74
703	.794	.634	.710	S.	S.	S.	2	12	2	5.3	South.	6	5	2	.....	.....
544	.712	.675	.677	S.	NE.	NE.	2	4	12	5.0	N. 49 E.	3	6	3	.....	.30
712	.655	.738	.702	W.	W.	W.	2	2	4	2.7	West.	5	4	6	.....	.....
534	.712	.655	.667	SW.	SW.	SW.	2	2	2	2.0	S. 45 W.	3	4	5	.....	.....
534	.750	.812	.729	S.	S.	S.	4	12	2	6.0	South.	3	3	4	.....	.....
754	.829	.807	.797	S.	N.	NW.	2	2	2	0.7	N. 45 W.	4	6	5	.....	.....
320	.644	.556	.673	S.	NE.	NE.	2	35	25	19.7	N. 47 E	4	10	4	.....	.....
582	.553	.520	.552	NW.	NW.	NW.	35	45	25	35.0	N. 45 W.	4	5	4	.....	.....
534	.675	.738	.582	S.	S.	S.	35	12	35	27.3	South.	3	4	6	.....	.....
902	.732	.675	.736	S.	SW.	SW.	2	2	4	2.7	S. 32 W.	4	3	7	.....	.60
398	.750	.732	.727	S.	S.	S.	2	12	25	13.0	South.	5	10	10	.....	.34
705	.712	.675	.697	NW.	NW.	NW.	2	12	4	6.0	N. 45 W.	5	4	6	.....	.....
984	.775	.712	.690	S.	SW.	NE.	2	4	12	2.3	N. 58 E.	4	3	5	.....	.....
719	.847	.820	.795	S.	S.	S.	12	12	4	9.3	South.	7	2	4	.....	.....
797	.726	.712	.745	W.	W.	W.	12	4	2	6.0	West.	4	3	5	.....	.....
761	.802	.675	.746	S.	NW.	NE.	2	4	12	3.7	N. 31 E.	4	5	5	.....	.....
865	.634	.702	.667	N.	NE.	NE.	4	12	4	6.3	N. 37 E.	4	5	9	.....	.....
712	.655	.850	.739	NE.	NE.	NE.	12	4	2	6.0	N. 45 E.	9	10	6	.....	.....
534	.655	.712	.667	NE.	NE.	NE.	2	12	25	13.0	N. 45 E.	4	10	10	.....	.16
754	.622	.692	.689	W.	W.	W.	2	4	2	2.7	West.	5	6	4	.....	.....
599	.732	.698	.676	NE.	SW.	S.	2	12	12	7.0	S. 20 W.	5	4	3	.....	.04
794	.712	.610	.705	W.	W.	W.	12	4	12	9.3	West.	6	4	5	.....	.....
712	.754	.702	.723	W.	NE.	W.	2	4	12	4.0	N. 77 W.	3	3	6	.....	.....
310	.698	.622	.643	SW.	SW.	SW.	2	2	2	2.0	S. 45 W.	3	2	5	.....	.....
761	.797	.768	.775	S.	NW.	NE.	2	4	2	1.7	S. 64 E.	3	4	5	.....	.....
794	.750	.698	.747	W.	W.	W.	12	2	2	5.3	West.	3	7	5	.....	.....
689	.716	.700	.702	.....	.....	.....	....	....	....	1.1	N. 82 W.	4.4	5.1	5.3	.....	2.18

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.																	
March 1	29.631	29.454	29.232	29.439	33	35	28	35	38	30	34.3	41	27	.162	.165	.130	.152
2	29.264	29.401	29.743	29.469	37	22	16	40	24	18	27.3	42	16	.181	.095	.067	.114
3	29.860	29.658	29.481	29.666	14	20	16	16	22	18	18.7	25	14	.059	.085	.067	.070
4	29.458	29.532	29.862	29.617	21	28	22	23	30	25	26.0	30	20	.090	.130	.084	.101
5	29.877	30.087	30.145	30.036	22	23	20	26	31	22	26.3	31	20	.072	.092	.085	.083
6	30.189	30.107	30.024	30.107	20	30	21	23	32	24	26.3	32	20	.074	.144	.079	.099
7	29.694	29.578	30.002	29.758	23	30	23	26	33	26	28.3	33	23	.089	.132	.089	.103
8	30.205	30.233	30.189	30.209	17	35	30	20	38	33	30.3	38	20	.060	.165	.132	.119
9	30.044	30.003	29.919	29.989	25	32	25	27	35	27	29.7	36	24	.112	.142	.112	.122
10	29.772	29.586	29.368	29.575	30	43	38	32	46	40	39.3	47	30	.144	.238	.203	.195
11	28.726	29.618	29.823	29.722	33	32	27	36	35	29	33.3	41	26	.149	.142	.124	.138
12	29.689	29.536	29.786	29.670	28	30	25	30	32	27	29.7	33	25	.130	.144	.112	.129
13	29.810	29.596	29.684	29.697	27	33	27	30	36	30	32.0	36	26	.113	.149	.113	.125
14	29.955	29.973	30.030	29.986	11	16	13	14	18	15	15.7	34	11	.037	.067	.056	.053
15	30.125	30.065	30.293	30.161	7	20	15	11	23	17	17.0	23	7	.014	.074	.063	.050
16	30.189	30.072	29.807	30.023	16	28	22	18	30	24	24.0	30	16	.067	.130	.095	.097
17	29.374	29.609	29.586	29.523	21	34	24	23	32	25	26.7	32	20	.090	.....	.117	.104
18	29.830	29.842	29.893	29.855	11	26	18	13	28	22	21.0	30	11	.049	.117	.053	.073
19	29.985	30.015	30.147	30.049	14	31	24	16	33	27	25.3	33	14	.059	.151	.095	.102
20	30.264	30.266	30.193	30.241	22	31	25	23	33	26	27.3	34	22	.107	.151	.118	.125
21	30.033	29.942	29.830	29.935	30	31	24	31	34	25	30.0	35	23	.155	.139	.117	.137
22	29.853	29.947	29.970	29.923	30	34	27	32	36	30	32.7	36	26	.144	.170	.113	.142
23	29.960	30.022	29.897	29.960	28	40	31	31	42	33	35.3	42	28	.119	.221	.151	.164
24	29.820	29.827	29.629	29.759	32	40	34	34	41	35	36.7	43	32	.155	.235	.183	.191
25	29.629	29.915	30.090	29.878	33	30	24	36	32	26	31.3	38	24	.149	.144	.106	.133
26	30.065	30.037	29.885	29.996	23	30	25	25	33	27	28.3	33	23	.109	.132	.112	.115
27	29.549	29.484	29.582	29.538	23	25	18	25	28	20	24.3	30	18	.103	.100	.076	.093
28	29.666	29.541	29.734	29.647	24	31	28	26	34	30	30.0	36	26	.106	.139	.130	.125
29	29.667	29.652	29.589	29.636	26	40	29	28	41	30	33.0	40	26	.117	.244	.149	.170
30	29.549	29.674	29.562	29.595	31	42	32	33	43	34	36.7	43	31	.151	.254	.155	.187
31	29.618	29.681	29.709	29.669	34	46	38	36	48	40	41.3	50	33	.170	.284	.213	.219
Means....	29.818	29.805	29.828	29.817	24.1	31.2	24.8	26.4	33.6	27.0	29.0	50	7	.107	.150	.112	.123
April 1	29.113	29.389	29.294	29.265	38	36	28	38	39	30	35.7	46	28	.129	.123	.130	.144
2	29.534	29.592	29.874	29.667	34	40	28	36	41	31	36.0	45	28	.170	.215	.119	.173
3	30.117	30.150	30.005	30.091	26	38	29	28	40	30	32.7	44	26	.117	.203	.149	.156
4	29.794	29.536	29.586	29.637	33	44	38	35	46	40	40.3	47	33	.162	.262	.203	.209
5	29.362	29.464	29.287	29.371	34	36	29	35	38	30	34.3	45	29	.183	.186	.149	.173
6	29.542	29.666	29.589	29.599	27	40	28	29	42	31	34.0	43	27	.124	.221	.119	.155
7	29.499	29.576	29.724	29.600	40	41	36	42	44	37	41.0	45	36	.221	.218	.199	.213
8	29.686	29.749	29.982	29.806	36	34	28	38	36	30	34.7	42	27	.186	.170	.130	.162
9	30.067	30.037	29.873	29.999	29	36	30	31	38	32	33.7	39	28	.137	.186	.144	.156
10	29.742	29.616	29.529	29.629	32	32	29	33	35	31	33.0	36	29	.168	.142	.137	.149
11	29.649	29.731	29.782	29.721	26	33	30	28	35	32	31.7	35	26	.117	.162	.144	.141
12	29.626	29.678	29.734	29.679	34	55	37	34	57	39	43.3	57	36	.196	.407	.194	.266
13	29.789	29.929	29.885	29.868	36	35	29	38	37	30	35.0	42	29	.186	.178	.149	.171
14	30.010	29.907	29.839	29.919	33	40	31	34	41	33	36.0	42	30	.175	.235	.151	.187
15	29.796	29.694	29.552	29.681	32	47	46	10	60	48	49.3	60	41	.077	.426	.224	.242
16	29.539	29.604	29.532	29.558	45	40	35	48	43	37	42.7	48	34	.260	.208	.178	.215
17	29.734	29.778	29.869	29.794	36	44	37	38	46	40	41.3	47	36	.186	.262	.181	.210
18	30.085	30.102	30.010	30.066	34	40	38	37	42	40	39.7	49	34	.157	.221	.203	.194
19	29.863	29.817	29.626	29.769	34	38	34	37	41	35	37.7	42	34	.157	.190	.183	.177
20	29.604	29.348	29.472	29.475	40	62	49	41	64	51	52.0	65	40	.235	.529	.321	.362
21	29.704	29.551	29.549	29.601	40	46	42	41	48	45	44.7	50	40	.235	.284	.238	.249
22	29.346	29.221	29.577	29.381	31	32	29	33	35	31	33.0	41	28	.151	.142	.137	.143
23	29.873	29.877	29.957	29.903	31	37	34	34	40	36	36.7	40	31	.139	.181	.170	.163
24	29.973	29.820	29.909	29.901	32	33	32	35	36	35	35.3	40	31	.143	.149	.142	.144
25	30.014	30.077	29.925	30.005	34	46	40	35	48	42	41.7	50	34	.183	.284	.231	.233
26	29.947	29.741	29.662	29.783	41	60	52	43	61	55	53.0	62	40	.211	.505	.349	.355
27	29.762	29.997	30.103	29.954	34	32	31	37	35	33	35.0	51	31	.157	.142	.151	.150
28	30.296	30.085	29.963	30.115	28	36	33	30	38	34	34.0	40	28	.130	.186	.175	.164
29	29.860	29.794	29.672	29.775	35	50	42	37	52	45	44.7	52	34	.178	.334	.228	.247
30	29.656	29.574	29.689	29.640	44	47	52	46	50	55	50.3	56	43	.262	.283	.349	.298
Means....	29.753	29.737	29.735	29.742	34.3	41.3	35.2	36.4	43.6	37.3	39.1	65	26	.172	.243	.187	.201

the northern and northwestern lakes at Fort Niagara, New York.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.712	.655	.750	.706	W.	W.	W.	4	25	35	21.3	West	8	5	7	.....	.....
.648	.712	.509	.623	W.	SW.	SW.	12	25	35	23.0	S. 52 W.	5	6	8	.....	.....
.492	.675	.622	.596	SW.	SW.	SW.	12	35	25	24.0	S. 45 W.	4	7	8	.....	.....
.655	.807	.675	.712	S.	SW.	SW.	35	12	35	25.3	S. 26 W.	6	4	7	.....	.....
.754	.794	.675	.741	W.	S.	W.	4	35	12	13.0	S. 25 W.	6	8	10	.....	.28
.655	.794	.746	.732	W.	W.	W.	45	35	45	41.7	West	10	7	10	.....	.....
.110	.084	.840	.345	NW.	NW.	W.	45	60	25	41.7	N. 53 W.	7	10	7	.....	.....
.556	.598	.541	.565	W.	W.	W.	25	12	4	13.7	West	7	4	6	.....	.....
.584	.675	.556	.605	SW.	SW.	SW.	2	2	2	2.0	S. 45 W.	10	7	8	.....	.....
.738	.655	.721	.705	W.	W.	W.	4	12	4	6.7	West	10	6	5	.....	.12
.682	.622	.702	.669	W.	W.	W.	2	2	4	2.7	West	5	4	6	.....	.....
.648	.659	.457	.588	NW.	W.	W.	12	2	4	5.7	N. 60 W.	5	3	6	.....	.....
.648	.509	.635	.597	NE.	NE.	N.	25	4	4	10.7	N. 40 E	6	4	7	.....	.....
.525	.541	.645	.567	SW.	SW.	SW.	2	2	4	2.7	S. 45 W.	4	5	4	.....	.....
.610	.648	.623	.627	N.	W.	W.	4	2	4	2.7	N. 60 W.	3	4	5	.....	.....
.648	.622	.556	.609	S.	W.	W.	2	2	2	1.7	S. 67 W.	5	3	10	.....	.26
.721	.509	.582	.604	NE.	W.	NW.	4	25	35	18.0	N. 59 W.	10	7	5	.....	.....
.553	.418	.568	.513	N.	NW.	N.	35	25	35	29.7	N. 11 W.	5	4	6	.....	.....
.582	.525	.596	.568	W.	W.	W.	12	4	2	6.0	West	4	2	4	.....	.....
.610	.721	.659	.663	S.	NE.	E.	2	4	2	1.7	N. 81 E.	3	5	6	.....	.40
.556	.622	.702	.627	E.	W.	W.	4	2	4	0.7	West	5	6	10	.....	.08
.682	.598	.702	.661	W.	SW.	S.	2	2	2	1.7	S. 45 W.	4	3	5	.....	.....
.598	.655	.712	.655	W.	W.	W.	2	4	2	2.7	West	4	5	4	.....	.....
.754	.675	.610	.680	W.	W.	W.	2	2	4	2.7	West	4	4	6	.....	.....
.622	.634	.570	.609	E.	E.	E.	2	4	12	6.0	East	4	6	10	.....	.30
.644	.655	.712	.670	S.	S.	S.	25	12	25	20.7	South	4	3	5	.....	.....
.541	.570	.671	.594	SW.	SW.	SW.	25	12	35	24.0	S. 45 W.	4	6	7	.....	.....
.525	.584	.671	.593	S.	S.	W.	12	4	2	5.7	S. 7 W	6	4	5	.....	.....
.538	.418	.568	.508	W.	SW.	W.	4	12	4	6.3	S. 63 W.	3	4	6	.....	.....
.500	.598	.582	.560	S.	S.	S.	12	2	2	5.3	South	4	3	4	.....	.....
.570	.698	.675	.648	SW.	SW.	SW.	2	2	4	2.7	S. 45 W.	3	4	5	.....	.....
.602	.611	.639	.617	.....	.....	.....	....	....	....	7.2	S. 78 W.	5.1	5.0	6.5	.....	1.57
.738	.698	.675	.704	W.	W.	W.	4	12	4	6.7	West	6	5	4	.....	.....
.644	.675	.738	.686	W.	W.	NE.	2	12	25	6.0	N. 11 E.	3	7	6	.....	.74
.703	.794	.634	.710	S.	S.	S.	2	12	2	5.3	South	6	5	2	.....	.....
.644	.712	.675	.677	S.	NE.	NE.	2	4	12	5.0	N. 49 E.	3	6	3	.....	.30
.712	.655	.738	.702	W.	W.	W.	2	2	4	2.7	West	5	4	6	.....	.....
.634	.712	.655	.667	SW.	SW.	SW.	2	2	2	2.0	S. 45 W.	3	4	5	.....	.....
.634	.750	.812	.729	S.	S.	S.	4	12	2	6.0	South	3	3	4	.....	.....
.754	.829	.807	.797	S.	N.	NW.	2	2	2	0.7	N. 45 W.	4	6	5	.....	.....
.820	.644	.556	.673	S.	NE.	NE.	2	35	25	19.7	N. 47 E	4	10	4	.....	.....
.582	.553	.520	.552	NW.	NW.	NW.	35	45	25	35.0	N. 45 W.	4	5	4	.....	.....
.334	.675	.738	.582	S.	S.	S.	35	12	35	27.3	South	3	4	6	.....	.....
.802	.732	.675	.736	S.	SW.	SW.	2	2	4	2.7	S. 32 W.	4	3	7	.....	.60
.698	.750	.732	.727	S.	S.	S.	2	12	25	13.0	South	5	10	10	.....	.34
.705	.712	.675	.697	NW.	NW.	NW.	2	12	4	6.0	N. 45 W.	5	4	6	.....	.....
.584	.775	.712	.690	S.	SW.	NE.	2	4	12	2.3	N. 58 E.	4	3	5	.....	.....
.719	.847	.820	.795	S.	S.	S.	12	12	4	9.3	South	7	2	4	.....	.....
.797	.726	.712	.745	W.	W.	W.	12	4	2	6.0	West	4	3	5	.....	.....
.761	.802	.675	.746	S.	NW.	NE.	2	4	12	3.7	N. 31 E.	4	5	5	.....	.....
.665	.634	.702	.667	N.	NE.	NE.	4	12	4	6.3	N. 37 E.	4	5	9	.....	.....
.712	.655	.850	.739	NE.	NE.	NE.	12	4	2	6.0	N. 45 E.	9	10	6	.....	.....
.634	.655	.712	.667	NE.	NE.	NE.	2	12	25	13.0	N. 45 E.	4	10	10	.....	.16
.754	.622	.692	.689	W.	W.	W.	2	4	2	2.7	West	5	6	4	.....	.....
.599	.732	.698	.676	NE.	SW.	S.	2	12	12	7.0	S. 20 W.	5	4	3	.....	.04
.794	.712	.610	.705	W.	W.	W.	12	4	12	9.3	West	6	4	5	.....	.....
.712	.754	.702	.723	W.	NE.	W.	2	4	12	4.0	N. 77 W.	3	3	6	.....	.....
.610	.698	.622	.643	SW.	SW.	SW.	2	2	2	2.0	S. 45 W.	3	2	5	.....	.....
.761	.797	.768	.775	S.	NW.	NE.	2	4	2	1.7	S. 64 E.	3	4	5	.....	.....
.794	.750	.698	.747	W.	W.	W.	12	2	2	5.3	West	3	7	5	.....	.....
.689	.716	.700	.702	.....	.....	.....	....	....	....	1.1	N. 82 W.	4.4	5.1	5.3	.....	2.18

Reductions of the monthly meteorological register of the surveys of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
May. 1	29.502	29.409	29.694	29.535	34	35	34	36	38	36	36.7	50	34	.170	.165	.170	.168
2	29.867	30.055	30.150	30.024	30	34	31	32	37	33	34.0	42	30	.144	.157	.151	.151
3	30.259	30.266	30.135	30.220	30	32	28	32	35	30	32.3	36	27	.144	.142	.130	.139
4	30.019	29.837	29.755	29.870	36	56	47	39	59	50	49.3	60	36	.173	.409	.283	.288
5	29.622	29.606	29.672	29.633	52	60	46	55	62	49	55.5	62	46	.349	.491	.271	.370
6	29.694	29.631	29.739	29.688	45	47	41	48	49	44	47.0	50	40	.260	.297	.218	.258
7	29.726	29.744	29.761	29.744	38	42	38	41	45	40	42.0	46	38	.190	.228	.203	.207
8	29.556	29.516	29.494	29.522	33	41	38	36	43	41	40.0	44	33	.149	.231	.190	.190
9	29.352	29.484	29.518	29.451	35	42	37	38	45	40	41.0	45	35	.165	.228	.181	.191
10	29.556	29.494	29.586	29.545	41	52	47	43	55	50	49.3	56	41	.231	.349	.283	.288
11	29.656	29.741	29.716	29.704	40	52	48	42	55	52	49.7	57	40	.221	.349	.282	.284
12	29.945	29.929	29.887	29.920	41	51	48	43	54	50	49.0	55	41	.231	.335	.309	.292
13	29.758	29.551	29.346	29.552	42	40	37	44	42	40	42.0	50	37	.241	.221	.181	.214
14	29.394	29.336	29.489	29.406	42	49	40	45	51	42	46.0	51	40	.228	.321	.221	.257
15	29.389	29.394	29.511	29.431	40	47	40	43	49	42	44.7	49	40	.208	.297	.221	.242
16	29.616	29.688	29.644	29.649	42	53	51	45	56	54	51.7	54	42	.228	.363	.335	.309
17	29.897	29.686	29.761	29.781	40	40	50	43	53	50	48.7	53	40	.208	.321	.117	.215
18	29.937	29.951	29.857	29.915	44	52	47	45	54	50	49.7	54	43	.275	.362	.283	.307
19	29.971	29.949	29.809	29.910	44	49	42	46	52	45	47.7	53	41	.262	.308	.228	.266
20	29.684	29.718	29.661	29.688	40	45	44	43	48	45	45.3	50	40	.208	.260	.275	.248
21	29.616	29.583	29.364	29.521	45	47	42	48	49	45	47.3	50	41	.260	.297	.228	.262
22	29.324	29.388	29.391	29.368	48	47	42	50	49	45	48.0	59	40	.309	.297	.228	.278
23	29.268	29.474	29.641	29.461	41	43	40	43	46	41	43.2	46	40	.231	.238	.235	.235
24	29.682	29.646	29.673	29.669	44	57	48	46	60	51	52.3	60	42	.262	.426	.296	.328
25	29.664	29.581	29.492	29.579	51	59	47	54	61	51	55.3	61	46	.335	.473	.270	.359
26	29.636	29.661	29.788	29.695	49	51	47	47	53	50	50.0	55	44	.240	.348	.283	.290
27	29.915	29.839	29.772	29.875	43	52	47	45	55	50	50.0	56	45	.251	.349	.283	.294
28	29.817	29.634	29.655	29.702	44	44	42	46	47	44	45.7	48	42	.262	.249	.241	.251
29	29.613	29.636	29.663	29.637	45	54	52	48	56	54	52.7	57	45	.264	.391	.362	.338
30	29.758	29.763	29.834	29.785	47	60	55	52	62	58	57.3	62	47	.257	.491	.393	.380
31	29.946	29.995	29.890	29.944	42	52	49	45	55	52	50.7	60	42	.228	.349	.308	.295
Means....	29.721	29.706	29.715	29.714	41.1	48.2	43.1	44.0	50.8	45.9	46.9	62	27	.232	.314	.247	.264
June 1	29.881	29.780	29.582	29.748	45	51	47	48	53	50	50.3	59	45	.260	.348	.283	.297
2	29.537	29.592	29.556	29.562	57	62	65	60	65	68	64.3	66	52	.426	.516	.577	.506
3	29.311	29.443	29.458	29.404	59	62	57	61	64	60	61.7	65	57	.473	.529	.436	.476
4	29.689	29.686	29.616	29.664	59	63	58	61	66	60	62.3	67	58	.473	.536	.456	.488
5	29.830	29.837	29.651	29.773	52	60	59	55	63	61	59.7	64	54	.349	.478	.473	.433
6	29.646	29.691	29.501	29.613	60	77	75	63	80	77	73.3	82	60	.478	.887	.841	.735
7	29.651	29.675	29.630	29.652	65	74	63	68	76	65	69.7	80	62	.577	.812	.349	.646
8	29.830	29.841	29.919	29.863	58	61	58	60	63	60	61.0	65	55	.456	.510	.456	.474
9	29.915	29.939	29.869	29.908	52	66	67	55	63	70	62.7	71	51	.349	.478	.622	.483
10	30.005	30.044	29.937	29.995	56	63	59	58	65	60	61.0	65	55	.422	.549	.487	.486
11	30.087	29.977	29.949	30.005	58	63	58	61	66	60	62.3	66	57	.443	.536	.456	.478
12	29.859	29.911	30.194	29.988	60	71	68	62	73	70	68.3	73	60	.491	.731	.652	.627
13	29.994	30.068	29.893	29.985	64	72	68	66	75	71	70.7	75	63	.569	.744	.644	.652
14	29.999	29.818	29.795	29.871	62	71	70	64	74	73	70.3	80	61	.529	.718	.693	.647
15	29.876	29.751	29.708	29.778	65	73	68	68	76	70	71.3	79	65	.577	.771	.658	.669
16	29.799	29.987	29.838	29.875	70	70	77	71	73	80	74.7	80	70	.729	.693	.887	.770
17	29.949	29.846	29.705	29.833	63	66	67	65	68	70	67.7	70	53	.549	.612	.622	.594
18	29.859	29.919	29.954	29.911	64	67	62	66	70	65	69.0	71	61	.569	.622	.516	.569
19	30.125	30.026	29.981	30.044	55	67	65	57	70	67	64.7	72	55	.407	.622	.591	.540
20	30.104	30.038	30.047	30.063	60	62	60	62	64	63	63.0	70	60	.491	.529	.478	.499
21	30.067	30.119	29.970	30.052	55	61	58	57	64	61	60.7	65	55	.407	.497	.443	.449
22	30.009	30.002	29.885	29.965	60	68	63	62	70	66	66.0	70	60	.491	.658	.536	.562
23	29.929	29.982	29.829	29.913	65	70	64	67	72	65	68.0	72	64	.591	.706	.583	.627
24	29.774	29.743	29.713	29.743	65	70	65	68	72	67	69.0	72	65	.577	.706	.591	.625
25	29.676	29.583	29.708	29.655	67	65	60	70	68	63	67.0	69	60	.622	.577	.478	.559
26	29.879	29.998	29.834	29.904	66	67	65	69	70	67	68.7	72	60	.599	.622	.591	.604
27	29.768	29.725	29.638	29.710	67	70	68	70	74	70	71.3	75	66	.622	.679	.658	.653
28	29.914	29.839	29.856	29.870	60	65	71	62	68	74	68.0	74	59	.491	.577	.718	.595
29	30.002	29.791	29.638	29.844	59	70	68	61	71	70	67.3	72	58	.473	.720	.658	.617
30	29.493	29.387	29.380	29.420	71	80	81	74	83	84	80.3	85	68	.718	.962	*	.905
Means....	29.848	29.835	29.774	29.814	60.6	66.7	61.1	63.0	69.3	66.9	66.4	85	45	.507	.631	.568	.574

*1.016

the northern and northwestern lakes at Fort Niagara, New York.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.797	.719	.782	.766	SW..	NE...	NE...	2	4	2	1.3	N. 45 E	1	3	4	.....	.....
.732	.738	.682	.717	W....	W....	W....	12	25	12	19.7	West ..	4	2	2	.....	.....
.659	.721	.682	.687	SW..	NE...	NE...	4	2	12	3.3	N. 45 E.	4	4	4	.....	.12
.730	.782	.622	.711	N.....	W....	W....	12	2	2	4.3	N. 18 W.	7	4	5	.....	.....
.515	.184	.721	.473	W....	W....	W....	2	4	2	2.7	West...	4	5	6	.....	.....
.598	.794	.610	.667	SW..	NE...	NE...	2	12	4	4.7	N. 45 E	4	5	7	.....	.16
.634	.703	.634	.657	S	NW...	NW...	12	25	12	10.0	N. 61 W.	10	5	6	.....	.....
.556	.719	.703	.659	S	S	S	2	2	2	2.0	South ..	4	3	5	.....	.....
.761	.698	.761	.740	W....	NW...	NE...	2	2	12	3.7	N. 28 E.	6	5	6	.....	.....
.794	.767	.820	.794	W....	SW..	SW..	2	4	12	6.0	S. 50 W.	4	6	10	.....	.....
.705	.698	.775	.726	W....	NW...	NW...	4	12	4	6.3	N. 53 W.	4	5	6	.....	.30
.782	.794	.761	.779	W....	NW...	NW...	4	12	12	9.0	N. 51 W.	10	6	5	.....	.....
.675	.705	.675	.685	SW..	SW..	SW..	2	12	35	16.3	S. 45 W.	4	7	5	.....	.....
.457	.682	.648	.596	W....	SW..	SW..	25	12	4	12.7	S. 73 W.	5	6	4	.....	.....
.202	.598	.671	.490	S	S	S	2	4	2	7.2	South ..	4	5	6	.....	.....
.682	.782	.738	.734	S	NE...	NE...	2	12	25	12.0	N. 42 E	4	6	10	.....	.14
.730	.....	.872	.801	W....	W....	W....	2	12	25	13.0	West...	10	7	6	.....	.....
.623	.768	.449	.613	W....	W....	W....	4	12	4	6.7	West...	4	5	6	.....	.....
.659	.800	.644	.701	SW..	W....	W....	2	2	2	2.0	S. 77 W.	4	3	5	.....	.....
.864	.800	.818	.827	N	NE...	E.....	2	12	12	7.7	N. 63 E	4	5	4	.....	.....
.893	.712	.872	.826	E.....	E....	E.....	12	35	25	24.0	East ...	5	10	0	.....	.25
.794	.802	.675	.757	NE ...	NW...	NW...	2	2	2	1.7	N. 16 W.	10	6	5	.....	.....
.685	.879	.800	.771	S	NE...	NE...	2	2	2	1.0	N. 16 E	3	6	5	.....	.....
.792	.912	.898	.867	W....	NW...	NW...	2	2	2	1.7	N. 60 W.	3	5	10	.....	.02
.705	.794	.754	.764	W....	W....	W....	2	12	25	13.0	West...	6	7	6	.....	.....
.746	.703	.761	.736	NE ...	NW...	NW...	12	2	4	4.3	N. 19 E.	4	3	6	.....	.....
.746	.655	.702	.701	NE ...	NE ...	NE ...	12	35	25	24.0	N. 45 E.	10	10	6	.....	.....
.754	.712	.782	.749	W....	W....	W....	25	2	4	10.3	West...	4	3	5	.....	.....
.768	.914	.890	.857	W....	W....	W....	12	4	12	9.3	West...	4	3	4	.....	.....
.800	.916	.792	.836	S	S	S	4	2	4	3.3	South ..	3	4	5	.....	.....
.802	.850	.820	.824	W....	W....	W....	2	2	2	2.0	West...	3	2	6	.....	.....
.698	.742	.736	.726	.....	.....	.....	....	....	....	2.3	N. 62 W.	5.1	5.0	5.8	.....	.99
1.000	.726	.782	.836	S	S	S	4	12	4	6.7	South ..	10	10	6	.....	.10
.802	.912	.685	.800	W....	W....	W....	4	12	2	6.0	West...	4	5	6	.....	.....
.768	.820	.890	.826	W....	W....	E.....	2	2	12	2.7	East ...	4	3	4	.....	.....
.797	.843	.820	.820	W....	W....	W....	4	2	4	3.3	West...	4	5	10	.....	.81
.898	.811	.890	.866	NW...	W....	W....	4	4	12	6.3	N. 82 W.	10	6	7	.....	.....
.775	.829	.685	.763	NW...	NW...	SW..	12	4	4	5.7	N. 60 W.	5	4	6	.....	.....
.829	.756	.903	.829	W....	W....	W....	4	12	4	6.7	West...	4	5	5	.....	.....
.811	.802	.782	.798	NW...	NW...	NW...	2	4	2	2.6	N. 45 W.	10	10	7	.....	.24
.788	.811	.794	.798	W....	NW...	NW...	2	2	4	2.7	N. 58 W.	4	3	5	.....	.....
.893	.698	.788	.793	W....	W....	W....	2	12	25	13.0	West...	6	10	10	.....	.56
.768	.797	.794	.786	W....	W....	W....	12	2	4	6.0	West...	6	3	5	.....	.....
1.000	.874	.816	.897	SW..	SW..	SW..	4	2	2	2.6	S. 45 W.	4	3	3	.....	.....
.811	.807	.890	.836	E.....	E.....	E.....	4	25	12	13.7	East ...	4	5	6	.....	.....
.895	.912	.800	.869	W....	NE...	W....	2	4	2	1.0	N. 23 W.	3	6	5	.....	.....
.312	.822	.850	.661	S	S	S	2	4	12	6.0	South ..	7	10	10	.....	.....
.777	.750	.807	.778	SW..	NE...	S	2	2	2	0.7	South ..	5	6	4	.....	.....
.811	.843	.732	.795	W....	W....	W....	2	4	12	6.0	West...	3	4	5	.....	.....
.712	.829	.820	.787	W....	W....	W....	4	2	2	2.7	West ...	3	4	6	.....	.....
.712	.738	.898	.783	NW...	NW...	NW...	2	4	2	2.6	N. 45 W.	3	4	3	.....	.....
.912	.888	.859	.885	S	S	SW..	4	12	25	12.7	S. 28 W.	5	4	5	.....	.....
.912	.850	.762	.841	W....	W....	W....	4	2	2	2.7	West ..	4	3	5	.....	.36
.800	.698	.788	.762	NE ...	NW...	W....	12	4	12	4.3	N. 29 W.	10	10	5	.....	.....
.712	.732	.802	.749	W....	W....	W....	12	4	4	6.7	West...	6	4	5	.....	.....
.698	.705	.698	.700	NE ...	NE ...	NW...	2	4	4	2.7	N. 10 E	4	10	10	.....	.....
.898	.850	.829	.859	SW..	SW..	SW..	2	12	4	6.0	S. 45 W.	6	4	5	.....	.....
.833	.941	.805	.860	S	NW...	NW...	3	12	25	12.0	N. 47 W.	4	3	6	.....	.36
.712	.698	.800	.737	W....	W....	W....	12	4	2	6.0	West...	7	4	5	.....	.....
.782	.811	.895	.829	W....	NE...	NE...	2	12	12	7.7	N. 41 E	4	3	6	.....	.....
.807	.861	.762	.810	W....	SW..	SW..	4	12	25	13.3	S. 49 W.	3	5	7	.....	.08
.843	.786	.805	.811	W....	W....	S	2	2	12	4.3	S. 18 W.	9	6	5	.....	.48
.802	.807	.808	.806	.....	.....	.....	....	....	....	3.0	S. 81 W.	5.4	5.4	6.0	.....	2.99

Reductions of the monthly meterological register of the survey of

Date.		Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
						Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U. S. inches and decimals.			
		7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.						°	°	°	°	°	°	°	°	°				
July	1	29.686	29.741	29.773	29.733	65	67	62	68	70	65	67.7	73	62	.577	.622	.516	.572
	2	29.764	29.831	29.703	29.766	64	70	75	66	73	78	72.3	78	62	.569	.693	.527	.596
	3	29.603	29.660	29.618	29.627	69	79	68	72	82	74	76.0	82	63	.668	.949	.604	.740
	4	29.631	29.544	29.598	29.591	70	72	68	72	75	70	72.3	76	68	.706	.744	.658	.703
	5	29.666	29.583	29.498	29.582	61	58	55	63	60	57	60.0	70	55	.510	.456	.407	.458
	6	29.482	29.495	29.651	29.543	74	73	68	77	75	70	74.0	77	58	.799	.784	.658	.747
	7	29.688	29.799	29.802	29.763	70	70	68	72	73	70	71.7	73	62	.706	.693	.658	.686
	8	29.634	29.849	29.789	29.757	60	69	65	62	72	67	67.0	74	60	.491	.668	.591	.583
	9	29.809	29.803	29.809	29.807	58	63	64	59	68	65	64.0	70	58	.469	.509	.583	.520
	10	29.942	29.993	29.781	29.905	58	68	61	61	71	66	66.0	71	57	.443	.644	.569	.552
	11	29.688	29.622	29.585	29.632	70	77	70	73	80	72	75.0	81	70	.693	.887	.706	.762
	12	29.718	29.803	29.799	29.773	62	62	61	64	65	63	64.0	70	61	.529	.516	.510	.518
	13	29.909	30.039	30.037	29.995	60	64	58	62	65	60	62.3	70	57	.491	.583	.456	.510
	14	30.119	30.031	29.949	30.033	55	65	64	57	68	65	63.3	70	55	.407	.577	.563	.522
	15	29.927	29.804	29.723	29.818	64	74	71	67	76	73	72.0	81	67	.556	.812	.731	.700
	16	29.872	29.991	29.829	29.897	60	67	65	62	70	68	66.7	75	60	.491	.622	.577	.563
	17	29.979	29.931	29.999	29.790	61	70	62	63	71	65	66.3	72	60	.510	.729	.516	.588
	18	29.967	29.999	29.871	29.946	62	73	67	64	75	70	69.7	76	61	.529	.784	.622	.645
	19	29.954	29.919	29.859	29.911	62	65	64	65	68	65	66.0	70	62	.516	.577	.583	.559
	20	29.977	29.991	29.801	29.923	63	71	65	66	74	68	69.3	72	63	.536	.718	.577	.610
	21	29.736	29.660	29.570	29.655	67	72	67	69	75	70	71.3	75	66	.635	.744	.622	.667
	22	29.643	29.569	29.585	29.599	65	80	72	68	82	75	75.0	82	65	.577	.996	.744	.772
	23	29.720	29.842	29.800	29.787	68	80	72	71	82	75	76.0	83	68	.644	.996	.744	.795
	24	29.755	29.663	29.649	29.689	72	83	77	75	86	80	80.3	88	70	.744	1.087	.887	.906
	25	29.680	29.637	29.593	29.637	72	74	68	74	76	71	73.7	77	67	.757	.812	.644	.738
	26	29.600	29.542	29.721	29.621	70	72	67	73	77	70	73.3	76	66	.693	.718	.622	.678
	27	29.665	29.560	29.479	29.568	68	76	80	71	78	83	77.3	83	65	.644	.870	.982	.832
	28	29.584	29.521	29.557	29.554	78	83	73	80	86	75	80.3	86	73	.931	1.087	.784	.934
	29	29.686	29.791	29.904	29.794	65	66	67	68	69	70	69.0	71	65	.577	.599	.622	.599
	30	29.967	29.989	29.973	29.976	65	70	68	67	72	70	69.7	74	62	.591	.706	.658	.652
	31	29.912	29.839	29.605	29.785	60	75	70	62	78	72	70.7	79	60	.491	.887	.706	.695
Means....		29.773	29.776	29.739	29.756	65.1	71.2	67.2	67.2	74.0	70.1	70.4	88	55	.596	.745	.643	.661
Aug.	1	29.698	29.600	29.613	29.637	67	70	68	70	73	70	71.0	74	67	.622	.693	.658	.658
	2	29.605	29.620	29.628	29.618	66	70	68	68	73	71	70.7	74	66	.612	.693	.644	.650
	3	29.852	29.909	29.943	29.901	61	70	68	64	72	70	68.7	73	68	.497	.706	.658	.620
	4	30.094	29.939	29.905	29.979	60	78	72	62	81	75	72.7	81	65	.491	.918	.744	.718
	5	29.931	29.952	29.887	29.923	70	77	75	72	80	77	76.3	82	70	.706	.887	.841	.811
	6	29.953	29.989	29.853	29.932	70	80	70	73	82	75	76.7	82	69	.693	.996	.666	.785
	7	29.915	29.995	29.810	29.907	71	79	73	73	79	76	76.0	80	71	.731	.990	.771	.831
	8	29.865	29.784	29.777	29.809	71	78	74	73	80	76	76.3	80	70	.731	.931	.812	.825
	9	29.828	29.864	29.744	29.812	70	80	79	72	82	80	78.0	82	70	.706	.996	.977	.893
	10	29.881	29.990	29.965	29.945	70	75	72	72	77	74	74.3	80	70	.706	.841	.757	.768
	11	29.991	29.917	29.923	29.944	66	72	67	68	75	70	71.0	75	66	.612	.744	.622	.659
	12	29.837	29.782	29.670	29.763	60	80	73	62	83	76	73.7	83	60	.491	.982	.771	.748
	13	29.447	29.432	29.548	29.476	72	74	68	75	76	70	73.7	76	67	.744	.812	.658	.738
	14	29.669	29.680	29.760	29.703	65	70	68	67	73	70	70.0	67	65	.591	.693	.658	.647
	15	29.929	29.963	29.865	29.919	63	73	70	65	75	72	70.7	75	62	.549	.784	.706	.680
	16	29.794	29.809	29.718	29.774	66	72	68	69	75	70	71.3	75	65	.599	.744	.658	.667
	17	29.760	29.574	29.500	29.611	66	78	72	68	80	74	74.0	82	65	.612	.931	.757	.767
	18	29.570	29.522	29.600	29.564	69	83	72	71	85	75	77.0	85	69	.682	1.101	.744	.842
	19	29.736	29.771	29.803	29.770	62	69	67	65	71	69	68.3	80	64	.516	.682	.635	.611
	20	29.854	29.963	29.796	29.871	63	68	67	64	71	70	68.3	75	63	.562	.644	.622	.609
	21	29.877	29.818	29.753	29.783	65	71	69	66	73	71	70.0	74	64	.604	.731	.692	.676
	22	29.887	29.732	29.663	29.761	62	72	67	64	75	70	69.7	75	61	.529	.744	.622	.632
	23	29.666	29.584	29.510	29.587	63	79	74	65	81	76	74.0	82	62	.549	.963	.812	.775
	24	29.648	29.658	29.701	29.669	65	73	63	68	76	65	69.7	77	62	.577	.771	.549	.632
	25	29.902	29.849	29.906	29.886	58	65	61	61	70	70	67.0	73	58	.443	.550	.416	.470
	26	29.907	29.827	29.793	29.842	61	69	67	65	75	72	70.7	75	61	.483	.628	.545	.589
	27	29.801	29.691	29.534	29.675	68	74	72	73	87	80	80.0	87	67	.618	.664	.677	.653
	28	29.460	29.410	29.620	29.497	70	73	67	75	80	74	76.3	82	66	.666	.717	.568	.650
	29	29.630	29.726	29.724	29.693	57	60	55	64	69	60	64.3	70	60	.373	.398	.367	.379
	30	29.854	29.967	29.980	29.934	50	54	51	56	63	60	59.7	65	50	.282	.298	.253	.278
	31	29.885	29.610	29.706	29.734	53	56	57	58	68	63	63.0	71	52	.336	.290	.386	.337
Means....		29.779	29.772	29.748	29.762	64.5	72.3	68.2	67.4	76.1	71.6	71.7	87	50	.578	.759	.654	.664

the northern and northwestern lakes at Fort Niagara, New York.

VAPOR.				WIND.							Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											o					
.802	.719	.802	.774	NE	W	W	25	35	4	9.0	N. 39 W	10	10	6	.....	.50
.794	.712	.800	.769	W	W	W	25	12	4	13.7	West...	3	4	5	.....	.....
.794	.698	.782	.758	SW ...	NE ...	NE ...	2	2	12	4.0	N. 45 E.	4	3	6	.....	.....
.726	.819	.786	.777	S	S	S	2	12	4	6.0	South ..	4	6	10	.....	.....
.805	.884	.781	.823	SW ...	SW ...	SW ...	25	12	4	13.7	S. 45 W	6	5	6	.....	.....
.777	.853	.756	.795	W	W	W	2	2	4	2.7	West...	7	10	6	.....	.20
.738	.762	.820	.773	W	W	W	2	2	2	2.0	West...	4	5	4	.....	.....
.705	.833	.738	.759	N W ..	NW ...	NW ...	12	4	12	9.3	N. 45 W	5	4	10	.....	.22
.719	.762	.732	.738	W	W	W	4	2	12	6.0	West...	10	5	6	.....	.....
.833	.805	.786	.808	W	W	W	2	4	2	2.7	West...	4	3	4	.....	.....
.829	.805	.727	.787	W	W	W	2	2	2	2.0	West...	3	2	3	.....	.....
.833	.842	.856	.830	W	W	W	4	2	2	2.7	West...	4	3	5	.....	.....
.836	.829	.732	.799	W	NE ...	NE ...	2	12	25	12.0	N. 43 E.	7	10	10	.....	.26
.762	.859	.829	.817	SW ...	SW ...	N	4	2	12	5.7	S. 75 W	8	6	5	.....	.....
.750	.853	.829	.811	W	W	W	2	4	12	6.0	West...	7	6	10	.....	.08
.762	.809	.802	.791	W	W	W	4	2	4	3.3	West...	5	3	4	.....	.....
.750	.798	.322	.623	W	W	W	2	4	12	6.0	West...	6	4	5	.....	.....
.920	.867	.786	.858	W	W	W	4	2	2	2.7	West...	6	4	5	.....	.....
.843	.794	.762	.800	W	W	NW ...	2	2	2	2.0	N. 76 W	4	3	7	.....	.20
.750	.777	.920	.816	NE ...	N	NW ...	25	4	2	9.7	N. 35 E.	10	4	6	.....	.....
.777	.853	.762	.797	N	N	N	4	12	12	9.3	North ..	4	6	10	.....	.54
.856	.853	.762	.824	S	S	S	2	12	25	13.0	South ..	6	5	7	.....	.04
.833	.767	.912	.837	SW ...	SW ...	SW ...	4	12	12	9.3	S. 45 W	10	10	10	.....	.14
.843	.822	.790	.818	W	SW ...	SW ...	2	4	2	2.7	S. 58 W	5	4	3	.....	.....
.802	.882	.722	.802	S	S	S	2	12	25	13.0	South ..	4	7	6	.....	.08
.772	.864	.786	.807	W	W	W	2	2	4	2.7	West...	5	4	3	.....	.....
.840	.805	.786	.810	W	W	W	2	2	2	2.0	West...	2	6	4	.....	.....
.843	.772	.836	.817	E	E	E	2	25	25	17.3	East ...	4	7	6	.....	.....
.777	.872	.867	.939	W	NW ..	NW ...	2	2	2	1.7	N. 56 W	8	3	5	.....	.....
.660	.884	.816	.787	W	W	W	12	4	2	6.0	West...	4	3	6	.....	.10
.762	.805	.794	.787	W	W	W	2	2	2	2.0	West...	5	4	5	.....	.....
.787	.813	.780	.793	.....	.....	.....	....	....	....	2.3	S. 83 W.	5.6	5.1	6.1	.....	2.36
.777	.864	.786	.809	W	NE ...	NE ...	2	25	35	16.3	N. 43 E.	3	4	5	.....	.....
.822	.836	.843	.834	S	S	S	4	25	12	13.7	South ..	10	6	7	.....	.16
.822	.888	.822	.864	SW ...	SW ...	SW ...	4	4	2	3.3	S. 45 W	6	5	6	.....	.....
.882	.838	.880	.867	W	W	W	4	2	2	2.7	West...	4	3	4	.....	.....
.805	.831	.882	.839	SW ...	SW ...	SW ...	2	2	2	2.0	S. 45 W	3	2	3	.....	.....
.831	.867	.907	.868	S	S	S	4	2	2	2.7	South ..	2	4	5	.....	.....
.843	.906	.890	.880	SW ...	S	W	2	4	12	5.0	S. 68 W	3	5	7	.....	.....
.880	.886	.880	.882	E	E	E	4	12	4	6.7	East ...	4	3	5	.....	.....
.805	.831	.848	.828	W	W	W	2	2	2	2.0	West...	8	4	3	.....	.....
.876	.890	.940	.902	SE....	NE ...	NE ...	2	25	4	9.7	N. 49 E.	2	3	2	.....	.....
.825	.838	.880	.848	S	S	NW ...	12	2	2	4.3	S. 6 W.	3	4	5	.....	.22
.884	.902	.898	.895	S	S	S	4	4	12	6.7	South ..	6	5	4	.....	.....
.891	.858	.850	.866	W	W	W	2	2	2	2.0	West...	3	2	3	.....	.....
.888	.856	.854	.866	W	S	S	2	4	2	2.3	S. 17 W	5	4	3	.....	.....
.843	.860	.898	.867	W	W	S	2	12	4	5.0	S. 74 W	4	5	6	.....	.....
.949	.854	.867	.890	SE....	W	SW ...	2	2	2	1.0	S. 41 W	7	4	3	.....	.....
.890	.895	.848	.878	W	NW ...	SW ...	2	4	2	2.3	S. 79 W	4	5	6	.....	.....
.891	.848	.836	.858	W	W	W	12	4	12	9.3	West...	7	4	5	.....	.....
.874	.848	.893	.872	SW ...	W	W	2	2	2	2.0	S. 77 W	4	3	4	.....	.....
.884	.888	.831	.868	S	NE ...	NE ...	2	25	4	9.3	N. 48 E.	5	2	6	.....	.....
.874	.833	.825	.844	SW ...	NE ...	NE ...	2	12	2	4.0	N. 45 E.	7	4	3	.....	.....
.884	.898	.839	.873	W	NW ...	NW ...	2	4	2	2.7	N. 58 W	2	6	4	.....	.....
.893	.900	.044	.912	S	NE ...	NW ...	2	12	2	3.7	N. 44 E.	3	4	3	.....	.....
.843	.900	.893	.879	W	N	N	2	4	12	5.7	N. 7 W.	2	3	5	.....	.....
.848	.843	.831	.841	N	N	N	25	12	25	20.7	North ..	5	3	10	.....	.82
.846	.848	.893	.862	S	W	W	4	2	2	2.0	S. 45 W	5	4	3	.....	.....
.848	.910	.898	.852	S	NE ...	S	4	12	4	2.7	N. 86 E.	3	4	5	.....	.....
.884	.843	.856	.861	NW ...	W	W	35	2	2	12.7	N 45 W	4	1	3	.....	.....
.882	.949	.898	.910	SW ...	W	W	2	2	2	2.0	S. 76 W	1	1	1	.....	.....
.856	.871	.873	.867	W	W	W	12	35	25	24.0	West...	2	3	2	.....	.....
.863	.866	.869	.866	.....	.....	.....	....	....	....	0.9	N. 2 W.	4.2	3.7	4.3	.....	1.20

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Sept. 1	29.524	29.734	29.820	29.693	60	55	55	63	60	60	61.0	63	55	.478	.367	.367	.404
2	29.935	29.764	29.804	29.834	52	58	51	55	64	61	60.0	65	50	.349	.403	.242	.331
3	29.867	29.698	29.755	29.773	62	65	64	65	78	70	71.0	78	56	.516	.443	.516	.492
4	29.857	29.924	29.824	29.868	56	63	61	58	67	65	63.3	70	55	.422	.522	.483	.476
5	29.703	29.600	29.865	29.723	68	62	55	73	66	60	66.0	77	54	.618	.516	.367	.500
6	29.933	30.124	30.145	30.067	55	62	60	57	65	63	61.7	65	55	.407	.516	.478	.467
7	29.923	30.097	30.137	30.052	55	63	61	57	64	62	61.0	66	55	.407	.562	.523	.497
8	30.154	30.043	29.937	30.045	51	65	62	53	67	65	61.7	67	50	.348	.591	.516	.485
9	29.841	29.682	29.665	29.729	65	76	72	67	81	75	74.3	81	65	.591	.829	.744	.721
10	29.747	29.822	29.927	29.865	54	56	58	56	58	60	58.0	70	53	.391	.422	.456	.423
11	30.004	29.909	29.807	29.907	49	66	62	51	69	65	61.7	70	48	.321	.599	.516	.479
12	29.769	29.716	29.661	29.715	60	71	67	63	75	70	69.3	75	57	.478	.704	.622	.601
13	29.596	29.543	29.716	29.618	55	66	50	68	67	55	63.3	70	53	.261	.636	.433	.440
14	29.944	30.125	30.065	30.045	50	55	48	53	58	50	53.7	60	47	.321	.393	.309	.341
15	30.049	30.002	29.937	29.996	43	56	55	45	60	58	54.3	61	43	.251	.396	.393	.347
16	29.907	29.954	29.991	29.951	64	68	63	66	70	65	67.0	72	60	.569	.658	.549	.625
17	30.003	29.984	29.817	29.935	70	77	76	71	87	80	79.3	88	69	.721	.792	.843	.785
18	29.925	29.954	29.838	29.906	71	85	72	73	88	75	78.7	88	70	.731	1.102	.744	.892
19	30.081	29.944	29.819	29.948	62	65	62	65	68	65	66.0	74	62	.516	.577	.516	.536
20	29.713	29.787	29.957	29.819	72	70	60	75	72	63	70.0	73	60	.744	.706	.478	.643
21	30.067	29.994	29.977	30.013	56	61	61	59	65	63	62.3	83	55	.409	.483	.510	.467
22	29.935	29.811	29.929	29.892	52	70	65	54	72	68	64.7	72	51	.362	.706	.577	.548
23	29.229	29.837	30.095	29.720	51	52	47	54	55	50	53.0	67	47	.335	.349	.283	.322
24	30.163	30.069	29.817	30.016	45	70	65	47	73	68	62.7	73	44	.273	.693	.577	.514
25	29.784	29.768	29.981	29.844	63	57	53	66	60	55	50.3	68	53	.536	.426	.376	.446
26	30.039	30.032	29.945	30.005	49	52	50	51	54	51	52.0	56	49	.321	.362	.348	.344
27	29.892	29.844	29.772	29.836	41	56	53	44	59	55	52.7	60	41	.218	.409	.376	.334
28	29.745	29.633	29.498	29.625	51	72	68	53	75	70	66.0	76	50	.348	.744	.638	.589
29	29.546	29.636	29.667	29.616	62	52	48	64	54	50	56.0	68	48	.529	.362	.309	.400
30	29.924	30.065	29.994	29.994	40	42	40	43	45	42	43.3	54	40	.208	.228	.221	.219
Means....	29.860	29.870	29.872	29.867	56.1	62.9	59.0	59.0	66.5	62.0	62.5	88	40	.432	.551	.478	.487
Oct. 1	29.927	29.785	29.639	29.784	58	65	38	60	63	60	61.0	65	38	.456	.....	.....	.456
2	29.428	29.478	29.521	29.476	60	64	58	63	66	60	63.0	67	57	.478	.569	.456	.501
3	29.765	29.706	29.811	29.761	50	47	48	53	58	50	53.7	60	47	.321	.178	.309	.269
4	29.831	29.727	29.732	29.763	38	53	47	40	55	50	48.3	56	37	.203	.376	.283	.287
5	29.437	29.542	29.773	29.591	49	51	45	51	53	48	50.7	54	45	.321	.348	.260	.310
6	30.080	30.064	30.141	30.095	45	49	44	48	52	47	49.0	53	42	.260	.308	.249	.272
7	30.284	30.342	30.255	30.294	43	45	44	46	48	46	46.7	51	42	.238	.260	.262	.253
8	30.208	30.137	29.940	30.095	37	53	47	39	56	50	48.3	56	36	.194	.363	.283	.280
9	29.742	29.577	29.461	29.593	50	55	44	53	58	46	52.3	59	44	.321	.393	.262	.325
10	29.279	29.554	29.298	29.377	56	57	50	58	60	52	56.7	60	50	.422	.426	.334	.394
11	29.362	29.289	29.429	29.360	48	51	47	50	54	49	51.0	55	47	.309	.335	.297	.314
12	29.514	29.626	29.711	29.617	50	46	42	53	48	45	48.7	53	42	.321	.284	.228	.278
13	29.802	29.815	29.769	29.795	40	51	47	42	54	50	48.7	55	41	.221	.335	.283	.280
14	29.854	29.905	29.719	29.826	42	56	54	45	60	56	53.7	60	42	.228	.396	.391	.338
15	29.715	29.852	29.832	29.800	51	57	55	53	60	58	57.0	60	50	.348	.426	.393	.389
16	29.961	30.002	29.824	29.828	45	69	62	46	70	65	60.3	70	44	.286	.695	.516	.499
17	29.877	29.703	29.708	29.763	62	71	65	65	74	67	68.7	75	62	.516	.718	.591	.608
18	29.738	29.673	29.631	29.681	59	71	64	62	74	66	67.3	74	60	.469	.718	.569	.585
19	29.809	29.815	29.839	29.821	59	75	65	61	78	68	69.0	78	58	.473	.827	.577	.626
20	29.952	29.967	29.981	29.967	56	56	57	58	59	60	59.0	70	55	.422	.469	.426	.439
21	29.889	29.861	29.755	29.904	66	75	67	62	77	70	69.7	78	56	.....	.841	.622	.732
22	29.817	29.944	29.878	29.880	51	50	48	54	53	50	52.3	71	48	.335	.321	.309	.322
23	30.154	30.105	30.195	30.151	42	47	45	45	50	47	47.3	53	42	.228	.283	.273	.261
24	30.312	30.289	30.240	30.280	36	50	45	38	53	47	46.0	53	36	.186	.321	.273	.260
25	30.223	30.210	30.178	30.204	40	50	45	41	52	48	47.0	52	40	.235	.334	.260	.276
26	30.147	30.110	30.085	30.114	38	50	47	40	53	50	47.7	53	37	.203	.321	.283	.269
27	30.152	30.153	30.063	30.123	38	51	48	40	54	50	48.0	54	38	.203	.335	.309	.282
28	30.012	30.094	29.967	30.024	42	53	48	45	56	51	50.7	56	41	.228	.363	.296	.296
29	29.841	29.776	29.719	29.779	47	50	48	50	53	50	51.0	54	46	.283	.321	.309	.304
30	29.732	29.729	29.663	29.708	46	52	45	48	55	48	50.3	55	45	.284	.349	.260	.298
31	29.707	29.802	29.934	29.814	46	45	38	48	47	40	45.0	50	45	.284	.273	.303	.253
Means....	29.859	29.859	29.829	29.849	48.1	55.3	49.9	50.2	58.2	53.0	53.8	78	36	.309	.414	.345	.343

the northern and northwestern lakes at Fort Niagara, New York.

VAPOR.				WIND.							Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation=1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.843	.848	.836	.842	N.....	N.....	W.....	4	2	2	2.3	N. 17 W	3	2	3	.....	.22
.891	.854	.863	.869	W	W	W.....	2	2	2	2.0	West...	3	1	2	.....	.....
.852	.870	.720	.814	W	W	W.....	2	2	2	2.0	West...	2	3	4	.....	.....
.900	.858	.898	.885	W	N.....	N.....	4	4	2	2.7	N. 30 W	3	4	1	.....	.....
.886	.880	.874	.880	NE ...	NE ..	NE....	4	12	2	6.0	N. 45 E	4	2	3	.....	.08
.862	.904	.898	.888	S	W	W.....	12	4	2	4.7	S. 26 W.	4	2	1	.....	.....
.900	.854	.898	.884	S	W	W.....	4	12	2	5.0	S. 74 W.	2	1	1	.....	.....
.824	.852	.893	.876	W	W	SW ...	2	2	2	2.0	S. 73 W.	2	1	3	.....	.09
.939	.743	.944	.875	NW ..	N.....	W.....	2	12	2	4.7	N. 14 W	1	2	1	.....	.....
.825	.850	.891	.855	W	S	S.....	2	4	4	3.0	S. 13 W.	4	5	4	.....	.....
.854	.867	.900	.874	W	S	SW ...	4	12	2	4.7	S. 22 W.	3	5	3	.....	.....
.888	.836	.886	.870	W	W	W	12	2	2	5.3	West...	3	2	1	.....	.....
.884	.944	.880	.903	W	W	W	4	12	2	6.0	West...	2	3	2	.....	.....
.874	.843	.944	.887	S	NE ...	NE....	2	12	4	5.0	N. 49 E	1	2	3	.....	.....
.841	.906	.902	.883	S	N	S.....	4	12	25	5.7	South ..	3	5	10	.....	.32
.884	.848	.843	.858	W	W	W	12	2	2	5.3	West...	2	1	2	.....	.....
.886	.949	.836	.890	W	W	W	4	2	2	2.7	West...	1	1	2	.....	.....
.898	.904	.848	.880	W	W	W	2	2	2	2.0	West...	1	1	2	.....	.....
.836	.843	.944	.874	E	NW ..	W	12	4	2	2.7	N. 70 E	3	1	2	.....	.....
.838	.856	.843	.846	NE ...	W	W	12	2	2	3.3	N. 27 E.	2	1	2	.....	.....
.896	.858	.848	.867	W	W	W	4	4	2	3.3	West...	3	4	5	.....	.....
.843	.912	.858	.871	W	W	W	2	4	2	2.7	West...	4	4	2	.....	.....
.850	.912	.858	.873	W	NW ..	W	2	2	4	2.7	N. 80 W.	3	2	2	.....	.....
.858	.875	.867	.867	S	W	W	2	4	12	5.7	S 83 W.	2	3	4	.....	.....
.903	.906	.850	.886	W	W	W	4	2	2	2.7	West...	5	3	2	.....	.....
.854	.774	.848	.825	N.....	NE	NW...	12	4	2	5.6	N. 5 E..	2	3	2	.....	.....
.850	.908	.871	.876	W	NW ..	S	2	4	12	3.3	S. 26 W.	1	3	2	.....	.....
.910	.875	.904	.896	S	S	S	12	35	12	19.7	South ..	4	3	2	.....	.06
.843	.846	.848	.846	NW ..	NW...	NW...	4	25	12	13.7	N. 45 W.	1	2	2	.....	.....
.893	.900	.898	.897	W	W	W	25	2	2	9.7	West...	1	1	2	.....	.....
.884	.863	.900	.882	S	S	S	2	12	2	5.3	South ..	2	4	2	.....	.....
.872	.869	.857	.872	.....	.....	.....	....	....	....	2.1	S. 79 W.	2.5	2.5	2.6	.....	.77
.848	.854	.898	.833	S	S	S.....	12	2	2	5.3	South ..	1	5	4	.....	.44
.895	.854	.850	.866	SW ..	SW ...	SW ...	2	4	2	2.6	S. 45 W.	5	2	3	.....	.....
.833	.900	.898	.877	NW ..	W	S	4	2	2	1.7	N. 81 W.	2	1	1	.....	.....
.884	.868	.858	.870	SW ...	S	S	2	12	4	6.0	S. 5 W..	2	3	2	.....	.....
.900	.867	.907	.891	SW ...	SW ...	S	2	2	2	1.7	S. 34 W.	1	1	4	.....	.....
.854	.912	.768	.845	S	W	W	2	2	2	1.7	S. 67 W.	2	5	3	.....	.....
.902	1.000	.860	.921	W	NW ..	S	2	2	2	1.3	S. 80 W.	3	4	2	.....	.....
.902	.910	.906	.906	SW ...	N.....	SW ..	2	2	2	1.0	S. 75 W.	1	4	5	.....	.....
.900	.912	.955	.922	S	N.....	SW ..	2	2	2	0.7	S. 45 W.	2	3	2	.....	.....
.900	.907	.903	.903	NW ..	W	W	12	2	12	8.0	N. 69 W.	3	1	2	.....	.....
.895	.858	.848	.867	W	NE	W	2	12	2	3.3	N. 27 E	2	3	2	.....	.....
.884	.871	.860	.872	SW ...	SW ...	S.....	2	4	12	5.6	S. 15 W.	1	2	3	.....	.....
.858	.906	.898	.887	W	W	W	4	2	4	3.3	West...	4	3	2	.....	.....
.893	.854	.898	.882	NW ..	W	W	4	2	2	2.3	N. 66 W.	3	1	2	.....	.....
.890	.904	.900	.898	SW ...	NE ...	NW...	2	12	2	3.3	N. 33 E	3	2	3	.....	.....
.846	.858	.898	.867	NW ..	W	W	12	2	2	5.0	N. 56 W	4	2	4	.....	.....
.895	.910	.903	.903	SW ...	W	S.....	2	2	4	2.3	S. 32 W.	1	1	2	.....	.....
.899	.915	.858	.891	S	W	W	4	12	4	5.6	S. 76 W.	1	6	5	.....	.....
.876	.899	.896	.877	SW ...	W	W	4	12	4	6.3	S. 82 W.	4	3	3	.....	.....
.943	.850	.848	.880	S	W	W	2	2	2	1.7	S 67 W.	2	3	1	.....	.....
.945	.902	.899	.915	SW ...	NW ..	NW...	2	4	2	2.0	N. 62 W	2	1	2	.....	.....
.888	.858	.848	.865	SW ...	NW ..	N	2	12	2	4.3	N. 46 W.	1	3	1	.....	.....
.890	.911	.906	.899	SW ...	S	S.....	2	4	2	2.6	S. 10 W.	1	1	2	.....	.....
.843	.860	.890	.864	W	W	NW...	12	2	25	12.0	N. 61 W.	2	1	2	.....	.....
.825	.751	.570	.715	W	W	W	2	2	2	2.0	West...	1	1	1	.....	.....
.783	.724	.758	.755	SW ...	N	NE....	2	12	4	4.7	N. 6 E..	2	2	3	.....	.....
.761	.518	.661	.647	S	S	S.....	2	4	2	2.7	South ..	2	3	2	.....	.02
.768	.701	.677	.715	S	W	W	4	4	12	5.6	S. 76 W.	4	2	2	.....	.28
.625	.564	.708	.632	NW ..	SW ...	S	12	2	25	6.7	S. 29 W.	2	3	4	.....	.....
.627	.519	.493	.546	NW ..	W	S	2	2	2	1.3	S. 80 W.	2	1	1	.....	.....
.698	.424	.670	.597	S	S	S.....	4	12	4	6.7	South ..	2	4	6	.....	.72
.849	.856	.828	.845	.....	.....	.....	....	....	....	0.3	S. 74 W.	2.4	2.5	2.6	.....	1.46

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Nov. 1	29.836	29.599	29.432	29.622	41	56	47	43	58	49	50.0	58	41	.231	.422	.297	.317
2	29.329	29.446	29.592	29.432	54	53	47	55	56	50	53.7	56	44	.404	.363	.283	.350
3	29.557	29.192	29.148	29.299	44	47	40	45	49	42	45.3	51	40	.275	.297	.221	.264
4	29.563	29.751	29.830	29.715	40	44	38	43	46	40	43.0	50	38	.208	.262	.203	.224
5	30.076	29.865	29.918	29.953	30	44	34	32	47	38	39.0	47	30	.144	.249	.144	.179
6	30.080	30.067	30.072	30.073	35	38	35	38	41	37	38.7	46	35	.165	.190	.178	.178
7	30.188	29.789	29.666	29.881	30	44	39	32	47	46	41.3	47	30	.144	.249	.160	.184
8	29.503	29.526	29.496	29.538	43	62	57	46	65	60	57.0	65	42	.238	.516	.426	.427
9	29.444	29.589	29.658	29.564	58	57	47	60	59	50	56.3	60	47	.456	.439	.283	.393
10	29.795	29.699	29.734	29.743	48	56	50	51	57	52	53.3	57	47	.296	.436	.334	.356
11	29.667	29.856	29.776	29.766	40	35	32	43	37	34	38.0	45	32	.208	.178	.155	.180
12	29.771	29.887	29.839	29.832	34	35	28	37	38	30	35.0	38	27	.157	.165	.130	.151
13	29.678	29.710	29.895	29.761	33	35	30	35	37	32	34.7	37	30	.162	.178	.144	.161
14	29.285	29.449	29.711	29.482	36	40	32	38	43	35	38.7	43	28	.186	.208	.142	.179
15	29.944	30.052	29.721	29.906	30	31	30	32	34	33	33.0	40	30	.144	.139	.132	.138
16	29.513	29.756	29.856	29.708	38	35	31	40	37	33	36.7	41	31	.203	.178	.151	.177
17	29.572	29.586	29.799	29.652	31	37	30	33	40	32	35.0	40	30	.151	.181	.144	.159
18	29.861	29.884	29.818	29.854	16	22	20	18	25	22	21.7	36	15	.067	.084	.085	.079
19	30.152	30.142	30.071	30.122	20	30	29	23	32	31	28.7	31.5	29	.074	.144	.137	.118
20	29.807	29.671	29.706	29.728	40	45	44	41	48	46	45.0	48	40	.235	.260	.262	.252
21	29.842	29.934	29.925	29.900	34	40	30	36	43	33	37.3	44	30	.170	.208	.132	.170
22	29.834	29.932	29.898	29.888	34	52	44	37	55	47	46.3	55	34	.157	.349	.249	.252
23	29.822	29.832	30.043	29.899	46	50	44	48	53	47	49.3	56	44	.284	.321	.249	.285
24	29.898	29.740	29.857	29.832	43	52	41	46	55	44	48.3	57	40	.238	.349	.218	.268
25	29.763	29.640	29.643	29.682	48	52	46	51	55	48	51.3	55	45	.296	.349	.284	.310
26	29.724	29.866	29.945	29.845	37	40	32	40	42	35	39.0	45	32	.181	.221	.142	.181
27	30.055	29.876	29.869	29.933	33	39	36	35	42	40	39.0	45	33	.162	.199	.160	.174
28	29.800	29.866	29.884	29.850	35	40	38	38	43	40	40.3	44	38	.165	.208	.203	.192
29	29.530	29.282	29.450	29.421	40	41	37	42	44	40	42.0	45	36	.221	.218	.181	.207
30	29.553	29.678	29.743	29.658	15	15	12	18	17	14	16.3	22	12	.052	.063	.052	.056
Means....	29.751	29.739	29.764	29.751	36.9	42.2	36.7	39.2	44.8	39.3	41.1	65	12	.202	.254	.196	.217
Dec. 1	30.078	29.972	30.098	30.049	15	20	18	18	23	20	20.3	42	23	.052	.074	.076	.067
2	29.888	30.062	29.831	29.927	31	31	28	33	34	30	32.3	34	28	.151	.139	.130	.140
3	29.961	29.747	29.653	29.787	25	34	30	28	37	31	32.0	37	24	.100	.157	.155	.137
4	29.796	29.635	29.733	29.721	12	20	18	14	22	20	18.7	30	12	.052	.085	.076	.071
5	29.453	29.621	29.686	29.587	21	28	25	23	30	28	27.0	23	24	.090	.130	.100	.107
6	29.461	29.210	29.380	29.350	30	36	35	33	39	37	36.3	45	30	.132	.173	.178	.161
7	29.746	29.664	29.843	29.751	26	23	19	28	26	21	25.0	40	19	.117	.089	.084	.095
8	29.952	29.827	29.729	29.836	16	18	12	16	18	15	16.3	25	12	.090	.098	.041	.076
9	29.950	29.944	29.889	29.928	8	14	8	10	16	10	12.0	22	9	.040	.059	.040	.046
10	29.664	29.732	29.723	29.706	23	20	16	26	23	18	22.3	24	16	.089	.074	.087	.077
11	29.909	29.817	29.763	29.830	20	22	15	23	25	18	22.0	25	15	.074	.084	.058	.070
12	29.922	29.862	29.785	29.856	3	2	2	5	5	4	04.7	20	2	.027	.014	.025	.022
13	30.073	30.069	30.060	30.062	5	8	9	8	10	9	09.0	19	4	.021	.040	.065	.042
14	30.020	29.905	29.841	29.922	7	9	6	10	12	8	10.0	17	6	.026	.031	.034	.030
15	29.793	29.789	29.730	29.771	14	22	18	16	25	20	20.3	24	14	.059	.084	.076	.073
16	29.732	29.754	29.659	29.715	20	23	21	22	26	24	24.0	26	20	.085	.089	.079	.084
17	29.557	29.444	29.512	29.504	20	24	20	23	26	22	23.7	24	20	.074	.106	.085	.088
18	29.903	30.033	30.104	30.013	14	16	12	16	18	15	16.3	21	12	.059	.067	.041	.056
19	30.363	30.336	30.265	30.321	11	17	8	13	19	10	14.0	20	8	.049	.071	.040	.053
20	29.827	29.754	29.853	29.811	22	23	27	25	26	30	27.0	31	22	.084	.089	.113	.095
21	30.226	30.135	30.019	30.127	25	30	24	28	32	27	29.0	36	20	.100	.144	.095	.113
22	29.282	29.277	29.420	29.326	42	40	33	44	42	36	40.7	45	32	.241	.221	.149	.204
23	29.716	29.807	30.038	29.854	29	24	20	31	26	23	26.7	33	20	.137	.106	.074	.106
24	29.826	29.845	29.916	29.862	28	34	28	31	37	31	33.0	37	27	.119	.157	.119	.132
25	29.865	29.620	29.430	29.638	32	35	33	35	38	35	36.0	38	30	.142	.165	.168	.156
26	29.728	29.814	29.902	29.815	33	39	32	35	41	34	36.7	44	32	.162	.212	.155	.176
27	29.410	29.213	29.450	29.358	35	52	41	38	55	44	45.7	55	40	.165	.349	.218	.244
28	29.825	29.978	29.906	29.903	27	29	29	31	32	30	31.0	50	29	.101	.126	.149	.125
29	30.097	30.162	30.183	30.147	23	20	17	25	22	19	22.0	41	17	.100	.085	.071	.085
30	30.245	30.333	30.292	30.290	16	14	9	18	16	11	15.0	31	9	.067	.059	.043	.056
31	30.245	30.173	30.114	30.177	9	23	18	11	26	20	19.0	28	9	.043	.089	.076	.069
Means....	29.855	29.824	29.832	29.837	20.7	24.2	20.3	23.1	26.7	22.6	24.1	55	2	.092	.112	.092	.098

the northern and northwestern lakes at Fort Niagara, New York.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.831	.708	.708	.749	NW...	NW...	NE ...	12	25	35	17.0	N. 2 W.	5	3.	4	.....	.....
.805	.675	.452	.644	E	N	NE....	2	25	4	9.3	N. 10 E	2	2	3	.....	.....
.836	.463	.704	.668	S	S	S	4	25	12	13.7	South ..	2	2	4	.....	.32
.876	.790	.783	.816	S	E	NE ...	2	2	2	1.0	S. 79 E.	2	1	2	.....	.....
.761	.836	.708	.768	S	W	N	2	25	35	14.0	N. 37 W	1	5	6	.....	.16
.874	.836	.831	.847	E	NE...	NE ...	2	12	2	5.0	N. 49 E.	2	2	1	.....	.....
.874	.943	.942	.920	E	NE ...	NE ...	4	25	4	10.7	N. 50 E.	3	1	2	.....	.....
.864	.893	.836	.864	W	E.....	SW ...	2	4	12	3.7	S. 36 W.	2	2	2	.....	.....
.893	.784	.858	.845	SW ...	S	S	12	35	4	16.0	S. 10 W.	3	2	4	.....	.24
.872	.876	.880	.876	NW...	W	W	25	4	4	10.3	N. 55 W.	2	1	2	.....	.....
.859	.846	.836	.847	S	S	S	2	12	2	5.3	South ..	1	2	2	.....	.....
.831	.812	.848	.830	S	S	S	4	12	2	6.0	South ..	1	2	3	.....	.....
.381	.946	1.000	.776	S	S	NE ...	2	4	12	3.0	N. 74 E.	5	6	4	.....	.44
.798	.816	.856	.823	NE ...	NE ...	NE ...	4	12	2	6.0	N. 45 E.	1	2	1	.....	.....
.840	.765	.816	.807	N.....	NE ...	NE ...	2	12	25	13.0	N. 43 E.	3	2	3	.....	.....
.891	.898	.890	.893	W	S	S	4	12	4	5.7	S. 14 W.	1	4	3	.....	.....
.949	.618	.824	.797	SW...	W	S	2	12	4	4.7	S. 69 W.	2	1	2	.....	.....
.902	.878	.858	.879	SW ...	SW ...	S	4	25	2	10.0	S. 42 W.	1	2	5	.....	.26
.836	.843	.836	.838	NE ...	NE ...	NE ...	4	12	2	6.0	N. 45 E.	3	2	1	.....	.....
.858	.900	.831	.863	S	SW ...	SW ...	12	25	4	12.7	S. 32 W.	2	4	4	.....	.....
.819	.783	.886	.803	S	W	S	2	2	2	1.7	S. 24 W.	1	1	2	.....	.....
.867	.900	.843	.870	S	SW ...	SW ...	4	12	25	13.3	S. 41 W.	2	1	2	.....	.....
.802	.805	.786	.798	NE ...	NE ...	NE ...	12	4	2	6.0	N. 45 E.	2	1	2	.....	.....
.847	.854	.843	.848	SE....	S	S	2	2	2	2.0	S. 13 E	1	1	2	.....	.....
.838	.822	.869	.843	W	W	W	12	25	25	20.7	West ..	2	3	2	.....	.....
.859	.867	.929	.885	NE ...	NW ...	NW ...	12	2	2	4.3	N. 26 E.	3	1	2	.....	.....
.756	.819	.869	.815	S	SW ...	SW ...	2	2	2	1.7	S. 31 W.	3	1	1	.....	.....
.864	.858	.898	.873	W	SW ...	SW ...	2	12	4	6.0	S. 49 W.	2	2	2	.....	.....
.888	.867	.856	.870	SW ...	NE ...	NE ...	2	35	25	19.3	N. 45 E.	3	4	4	.....	.12
.750	.762	.829	.780	NE ...	SW ...	S	12	4	2	2.3	N. 58 E.	3	2	1	.....	.....
.831	.815	.830	.825	.....	.....	.....	....	....	....	0.7	N. 71 W	2.2	2.2	2.9	.....	1.54
.880	.....	.....	.880	S	S	S	2	4	2	2.7	South ..	2	1	2	.....	.....
.831	.891	.880	.867	S	S	S	12	4	12	9.3	South ..	2	2	2	.....	.....
.798	.370	.856	.675	N.....	N	NW...	25	2	2	9.3	N. 3 W.	3	2	2	.....	.....
.820	.869	.786	.825	S	NE ...	NE ...	2	12	4	5.0	N. 51 E.	2	3	3	.....	.78
.859	.864	.777	.833	E	W	W	4	12	25	11.0	West...	2	3	4	.....	.....
.777	.794	.772	.781	W	W	W	25	12	25	20.7	West ..	2	1	2	.....	.....
.767	.777	.843	.796	NE ...	NE ...	NE ...	12	4	2	6.0	N. 45 E.	1	2	1	.....	.....
.816	.809	.786	.804	SE....	E	E	2	2	2	2.0	S. 77 E.	1	1	2	.....	.....
.798	.816	.843	.819	S	S	S	4	2	4	3.3	South ..	2	3	3	.....	.....
.876	.822	.861	.853	S	S	S	12	25	4	13.7	South ..	2	2	3	.....	.06
.856	.802	.853	.837	S	S	S	2	2	2	2.0	South ..	3	4	3	.....	.14
.798	.850	.762	.803	NE ...	NE ...	NE ...	4	12	4	4.7	N. 45 E.	5	4	5	.....	.16
.829	.802	.786	.806	S	S	S	2	2	2	2.0	South ..	2	1	2	.....	.22
.762	.765	.872	.800	SE....	SW ...	SW ...	2	2	2	1.7	S. 16 W.	1	1	2	.....	.....
.864	.822	.816	.834	S	W	W	2	2	2	1.7	S. 69 W.	1	1	1	.....	.....
.921	.948	.836	.902	S	S	S	2	4	4	3.3	South ..	2	1	2	.....	.....
.836	.856	.893	.862	S	S	S	4	12	12	9.3	South ..	2	1	3	.....	.....
.828	.856	.891	.858	S	S	S	2	4	12	6.0	South ..	1	1	2	.....	.....
.882	.863	.843	.863	S	S	S	2	25	25	17.3	South ..	2	1	2	.....	.....
.876	.819	.522	.806	SE....	SE....	SE....	2	2	4	2.6	S. 45 E	2	1	4	.....	.....
.....	.907	.848	.878	S	S	S	4	4	2	3.3	South ..	2	2	2	.....	.....
.802	.798	.856	.819	W	W	W	25	35	4	21.3	West...	5	2	2	.....	.18
.762	.786	.847	.798	N.	NW ..	SW ...	2	2	2	2.0	N. 63 W.	1	1	2	.....	.....
.811	.798	.847	.819	W	W	W	2	2	2	2.0	West...	1	1	1	.....	.....
.912	.861	.777	.850	S	NE ...	NE ...	2	4	2	1.7	N. 64 E	2	1	2	.....	.....
.820	.798	.786	.801	SE....	NE ...	NE ...	2	4	2	2.0	N. 62 E.	1	1	2	.....	.....
.820	.802	.856	.826	SE....	NE ...	NE ...	2	2	4	2.0	N. 62 E.	1	2	2	.....	.....
.762	.809	.790	.787	E	E	E	2	4	12	6.0	East ...	2	0	5	.....	.....
.786	.798	.836	.813	E	NE...	NE ...	12	25	4	12.7	N. 58 E.	4	2	2	.....	.....
.850	.805	.777	.811	NE ...	S	S	4	2	2	1.0	S. 64 E.	1	1	2	.....	.....
.850	.847	.820	.839	W	W	W	25	35	35	31.7	West...	2	2	3	.....	.....
.828	.813	.827	.824	.....	.....	.....	....	....	....	2.2	S. 48 W.	2.0	1.7	2.4	.....	1.54

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Jan. 1	29.947	29.989	29.995	29.977	24	27	21	26	29	23	26.0	30	11	.106	.124	.090	.107
2	30.064	29.927	29.866	29.952	15	24	10	16	26	11	17.7	26	0	.071	.106	.057	.079
3	30.950	29.838	29.816	30.201	9	31	10	10	33	11	18.0	35	-10	.054	.151	.057	.087
4	29.849	29.820	29.809	29.826	24	38	27	25	40	29	31.3	40	3	.117	.203	.124	.148
5	29.527	29.245	29.296	29.356	25	32	29	26	34	30	30.0	35	14	.123	.155	.149	.142
6	29.416	29.406	29.501	29.441	29	28	27	30	30	28	29.6	35	16	.149	.130	.136	.138
7	29.642	29.589	29.545	29.592	22	22	21	24	25	23	24.0	28	10	.095	.084	.090	.090
8	29.553	29.419	29.437	29.470	19	23	21	20	25	22	22.3	26	4	.092	.100	.101	.098
9	29.465	27.311	29.267	29.348	22	30	23	23	32	26	27.0	32	3	.107	.144	.089	.113
10	29.197	29.231	29.349	29.259	21	31	24	22	32	25	26.3	34	11	.101	.162	.117	.127
11	29.463	29.583	29.635	29.560	19	29	22	20	31	23	24.7	31	8	.092	.137	.107	.112
12	29.987	30.046	30.026	30.020	10	18	14	11	19	15	15.0	23	3	.057	.087	.071	.072
13	29.676	29.471	29.473	29.540	14	15	15	15	17	16	16.0	19	2	.071	.063	.074	.069
14	29.773	29.725	29.746	29.748	15	18	10	16	19	11	15.3	21	- 1	.074	.087	.057	.073
15	29.749	29.873	29.869	29.830	9	14	9	10	16	10	12.0	16	- 2	.054	.059	.054	.056
16	29.836	29.617	29.435	29.626	10	20	21	11	22	23	18.7	23	-11	.057	.085	.090	.077
17	29.513	29.603	29.628	29.581	15	14	17	16	16	18	16.7	24	5	.074	.059	.083	.072
18	29.953	29.834	29.852	29.880	8	10	8	9	12	9	10.0	18	- 2	.051	.046	.051	.049
19	29.680	29.546	29.538	29.588	9	14	13	10	15	14	13.0	16	- 4	.054	.071	.067	.064
20	29.580	29.535	29.575	29.563	20	21	18	21	23	19	21.0	25	3	.096	.101	.067	.095
21	29.220	29.201	29.271	29.231	20	27	20	21	28	21	23.3	28	8	.096	.136	.096	.109
22	29.497	29.529	29.610	29.545	20	23	20	22	25	21	22.7	27	8	.085	.100	.096	.094
23	29.755	29.764	29.781	29.767	21	25	26	23	27	28	26.0	28	10	.090	.112	.117	.106
24	30.013	30.026	30.014	30.018	24	27	25	26	29	27	27.4	30	13	.106	.124	.112	.114
25	29.844	29.564	29.246	29.550	26	26	29	27	27	30	28.0	30	15	.129	.129	.149	.136
26	29.671	29.041	29.066	29.059	30	26	22	32	28	23	27.7	32	13	.144	.117	.107	.123
27	29.333	29.417	29.457	29.402	19	21	21	20	22	22	21.3	25	10	.092	.101	.101	.098
28	29.759	29.750	29.291	29.597	20	20	16	21	21	17	19.7	24	5	.096	.096	.079	.090
29	29.749	29.778	30.040	29.856	9	13	9	10	14	10	11.3	19	- 1	.054	.067	.054	.058
30	30.130	30.115	30.010	30.085	9	22	9	10	23	10	14.3	24	- 1	.054	.107	.054	.072
31	29.779	29.700	29.485	29.655	23	31	32	25	36	34	31.7	27	- 1	.100	.116	.155	.124
Means . . .	29.709	29.628	29.611	29.649	18.1	23.2	19.0	19.3	25.0	20.3	21.5	40	-11	.089	.108	.093	.097
Feb. 1	29.362	29.520	29.689	29.524	40	35	27	43	39	29	37.0	47	19	.208	.152	.124	.161
2	29.579	29.359	29.098	29.345	27	27	31	29	29	33	30.0	33	12	.124	.124	.151	.133
3	28.985	29.018	29.137	29.047	36	34	21	38	37	22	32.3	42	22	.186	.157	.101	.148
4	29.493	29.410	29.338	29.414	29	38	31	31	40	33	34.7	45	17	.137	.203	.151	.164
5	29.341	29.391	29.649	29.460	31	31	28	32	32	29	31.0	35	18	.162	.162	.142	.155
6	29.786	29.812	30.007	29.868	28	39	25	30	42	26	32.7	45	14	.130	.199	.123	.151
7	30.051	30.019	29.973	30.014	26	52	30	28	54	31	37.7	54	5	.117	.362	.155	.211
8	29.864	29.705	29.659	29.743	30	48	42	32	56	44	44.0	56	13	.144	.230	.241	.205
9	29.297	29.270	29.204	29.257	38	34	25	41	36	27	34.7	45	16	.190	.170	.112	.157
10	29.786	30.135	30.309	30.077	10	11	13	11	12	14	12.3	27	- 3	.057	.061	.067	.062
11	30.501	30.276	30.011	30.263	9	28	30	10	30	32	24.0	35	- 4	.054	.130	.144	.113
12	30.200	30.108	30.007	30.105	33	42	35	36	44	37	39.0	44	19	.149	.241	.178	.189
13	29.968	29.784	29.684	29.812	42	43	43	44	46	46	45.3	47	26	.241	.238	.238	.239
14	29.927	29.984	30.056	29.989	36	36	29	37	38	30	35.0	48	21	.199	.186	.149	.178
15	30.225	30.167	30.047	30.146	22	25	25	23	26	26	25.0	39	13	.107	.123	.123	.118
16	29.564	29.384	29.455	29.468	37	37	36	42	42	38	40.7	48	15	.153	.155	.186	.165
17	29.685	29.730	29.803	29.739	34	39	32	38	39	35	37.3	40	23	.144	.238	.142	.175
18	29.781	29.676	29.545	29.667	26	42	33	28	45	34	35.7	41	16	.117	.238	.175	.177
19	29.999	30.009	29.936	29.981	27	25	18	29	27	19	25.0	36	9	.124	.112	.087	.108
20	29.787	29.771	29.829	29.796	24	30	24	26	32	25	27.7	33	9	.106	.144	.117	.122
21	29.644	29.486	29.469	29.533	26	29	28	27	30	29	28.7	31	9	.129	.149	.142	.140
22	29.816	29.911	29.960	29.896	28	26	20	30	28	21	26.3	32	12	.130	.117	.096	.114
23	29.679	29.390	29.385	29.485	24	33	32	25	26	34	31.7	41	2	.117	.149	.155	.140
24	29.400	29.593	29.794	29.596	33	32	25	36	35	27	32.7	37	15	.149	.142	.112	.134
25	29.948	29.861	29.833	29.881	21	27	19	22	28	20	23.3	29	8	.101	.136	.092	.110
26	29.893	29.967	30.031	29.964	19	33	30	20	37	32	29.7	37	12	.092	.136	.144	.124
27	30.132	30.178	30.149	30.153	23	33	24	24	35	25	28.0	39	13	.119	.162	.117	.133
28	29.882	29.743	29.712	29.779	33	43	38	35	50	43	42.7	50	14	.162	.186	.164	.171
Means . . .	29.771	29.738	29.742	29.750	28.3	34.0	28.3	30.2	36.6	30.0	32.3	54	- 4	.137	.171	.140	.149

the northern and northwestern lakes at Fort Niagara, New York.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.833	.876	.853	.854	S.....	S.....	S.....	2	25	35	20.7	South..	1	2	2	.....	.....
.934	.809	.786	.843	SW....	SW....	W.....	12	25	35	22.3	S. 67 W.	2	1	2	.....	.....
.920	.853	.829	.867	NE....	NE....	S.....	2	12	35	9.0	S. 21 E	2	5	4	.....	.14
.750	.843	.820	.804	NW..	NW....	NW..	35	25	12	24.0	N.45 W.	2	1	2	.....	.....
.794	.772	.628	.731	SW....	W.....	W.....	12	25	4	12.7	S. 77 W.	2	2	2	.....	.....
.719	.736	.807	.788	N.....	NW....	NW....	4	2	2	2.3	N.24 W.	2	1	2	.....	.....
.794	.772	.533	.700	NE....	E.....	E.....	4	12	4	6.3	N. 82 W.	2	2	2	.....	.....
.767	.836	.822	.808	S.....	S.....	S.....	4	12	25	13.7	South..	2	2	3	.....	.....
.880	.878	.786	.848	S.....	S.....	S.....	12	4	4	6.7	South..	6	2	2	.....	.....
.790	.936	.861	.862	S.....	S.....	S.....	4	12	4	6.7	South..	1	1	2	.....	.....
.750	.807	.792	.783	SW....	SE....	SE....	4	4	4	3.0	S. 18 E.	1	3	2	.....	.....
.712	.719	.782	.738	N.....	NW..	NW..	4	25	35	21.0	N.42 W.	2	2	3	.....	.....
.797	.807	.794	.799	NW..	W.....	W.....	4	12	25	13.3	N.86 W.	2	2	2	.....	.....
.811	.750	.698	.753	SW...	W.....	W.....	4	25	35	20.7	S. 88 W.	3	2	3	.....	.....
.794	.712	.703	.736	N.....	SW....	W.....	12	2	12	5.7	N.52 W.	2	1	2	.....	.....
.820	.807	.800	.809	W.....	W.....	W.....	35	25	12	24.0	West...	1	2	2	.....	.....
.800	.732	.794	.775	SW...	SW....	SW....	4	12	25	13.7	S. 45 W.	2	2	3	.....	.....
.682	.622	.721	.675	N.....	N.....	S.....	4	4	2	2.0	North..	2	1	2	.....	.....
.598	.794	.788	.727	SW..	SW...	SW....	2	4	4	3.3	S. 45 W.	2	2	3	.....	.....
.912	.777	.843	.844	SW....	S.....	SW....	4	12	12	8.7	S. 26 W.	2	1	3	.....	.....
.802	.750	.703	.752	NE....	N.....	N.....	4	2	2	2.3	N. 24 E	1	1	2	.....	.....
.712	.805	.772	.763	W.....	SW....	W.....	4	2	2	1.3	N.52 W.	3	3	3	.....	.....
.850	.798	.772	.807	SW....	S.....	S.....	2	2	2	2.0	S. 13 W.	3	2	2	.....	.....
.767	.805	.756	.776	S.....	S.....	S.....	4	4	2	3.3	South..	1	2	3	.....	.18
.790	.805	.850	.815	S.....	S.....	W.....	4	12	25	10.0	S. 57 W.	4	1	4	.....	.12
.732	.829	.698	.753	W.....	W.....	W.....	4	2	4	3.3	West...	2	1	2	.....	.....
.797	.744	.645	.729	S.....	S.....	S.....	2	2	2	2.0	South..	2	2	2	.....	.....
.719	.750	.820	.763	W.....	W.....	W.....	2	2	2	2.0	West..	2	3	2	.....	.....
.829	.756	.732	.772	SW....	S.....	S.....	2	4	25	10.3	S. 3 W.	1	3	5	.....	.62
.525	.671	.635	.610	W.....	W.....	W.....	25	25	25	25.0	West...	2	2	1	.....	.....
.779	.785	.761	.775	.....	.....	.....	.....	.....	.....	6.1	S. 68 W.	2.1	1.9	2.5	.....	1.06
.525	.598	.702	.608	SW....	SW....	SW....	2	4	4	3.3	S. 45 W.	1	1	2	.....	.....
.800	.712	.782	.765	W.....	W.....	W.....	2	4	4	3.3	West...	3	1	2	.....	.....
.655	.712	.893	.753	W.....	W.....	W.....	4	2	12	6.0	West...	1	1	2	.....	.....
.635	.721	.702	.686	S.....	S.....	S.....	2	2	2	2.0	South..	1	2	2	.....	.....
.730	.782	.655	.722	W.....	W.....	W.....	4	4	25	11.0	West...	2	1	4	.....	.....
.703	.726	.807	.745	W.....	W.....	W.....	12	25	25	20.7	West...	1	3	4	.....	.....
.768	.634	.712	.705	N.....	N.....	W.....	35	25	35	23.3	N.30 W.	5	3	3	.....	.....
1.000	1.000	.475	.825	W.....	W.....	W.....	25	4	2	10.3	West...	3	2	3	.....	.....
.582	.659	.582	.608	W.....	SW....	W.....	2	2	2	2.0	S. 76 W.	2	1	1	.....	.....
.634	.598	.682	.638	NE....	NE....	S.....	25	4	2	9.0	N. 48 E	2	2	2	.....	.....
.598	.622	.525	.582	S.....	E.....	E.....	2	4	25	9.7	S. 86 E.	1	1	2	.....	.....
.500	.253	.480	.411	NE....	NE....	E.....	45	35	25	33.0	N. 55 E.	4	2	4	.....	.20
.334	.582	1.000	.639	E.....	E.....	S.....	35	25	2	23.3	S. 88 E.	2	1	1	.....	.....
.377	.418	.553	.449	S.....	S.....	S.....	2	2	2	2.0	South..	1	1	1	.....	.....
.659	.622	.702	.661	S.....	S.....	S.....	4	2	2	2.7	South..	2	1	1	.....	.....
.721	.634	.610	.655	W.....	W.....	W.....	2	4	2	2.7	West...	2	2	1	.....	.....
.598	.754	.721	.691	NE....	NE....	NE....	4	2	12	6.0	N. 45 E.	1	2	3	.....	.....
.659	.682	.475	.605	NE....	NE....	NE....	12	4	25	13.7	N 45 E	2	2	2	.....	.....
.623	.692	.582	.632	SW....	SW....	SW..	2	2	2	2.0	S. 45 W.	2	2	3	.....	.....
.622	.634	.675	.644	SW..	S.....	SW....	25	12	25	19.7	S. 37 W.	5	4	4	.....	.....
.655	.794	.644	.698	SW..	S.....	S.....	2	2	4	2.7	S. 10 W	1	1	4	.....	.52
.836	.829	.705	.790	S.....	S.....	S.....	25	12	4	13.7	South..	5	2	2	.....	.....
.788	.754	.598	.713	NW..	NW..	W.....	25	12	2	13.0	N.47 W.	2	2	1	.....	.....
.685	.712	.685	.694	W.....	W.....	W.....	2	12	2	5.3	West..	2	1	2	.....	.....
.698	.719	.797	.738	E.....	E.....	E.....	12	2	12	8.7	East....	2	2	4	.....	.....
.797	.824	.792	.804	S.....	S.....	SW....	2	2	4	2.3	S. 24 W.	1	1	3	.....	.38
.719	.805	.756	.760	S.....	SW..	SW....	2	12	2	5.0	S. 41 W.	5	5	2	.....	.....
.582	.694	.899	.722	E.....	E.....	E.....	4	2	4	3.3	East...	1	1	2	.....	.....
.746	.721	.692	.720	SW....	SW..	SW....	12	4	2	6.0	S. 45 W.	1	2	3	.....	.....
.682	.659	.596	.646	W.....	W.....	W.....	12	12	4	9.3	West...	1	2	2	.....	.....
.596	.634	.702	.644	S.....	S.....	S.....	2	2	4	2.7	South..	1	1	2	.....	.....
.661	.683	.683	.676	.....	.....	.....	.....	.....	.....	0.8	N.66 W.	2.1	1.8	2.4	.....	1.10

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
March 1	29.573	29.343	29.129	29.348	32	46	45	35	50	48	44.3	53	35	.142	.258	.260	.220
2	29.129	29.440	.....	29.285	42	20	....	44	21	....	32.5	.....	.....	.241	.096	....	.169
3	29.911	29.803	29.600	29.771	16	19	20	17	20	21	19.3	51	5	.078	.092	.096	.089
4	29.507	29.639	29.822	29.656	25	28	23	26	29	24	26.3	33	8	.123	.142	.112	.126
5	29.954	30.015	30.135	30.035	25	32	22	27	34	23	28.0	40	13	.112	.155	.107	.125
6	30.193	30.115	30.009	30.106	19	31	28	20	34	29	27.7	36	8	.092	.139	.142	.124
7	29.659	29.642	30.011	29.771	28	36	27	29	39	28	32.0	41	15	.142	.173	.136	.184
8	30.239	30.196	30.131	30.189	23	42	27	25	45	28	32.7	50	10	.100	.228	.136	.155
9	29.963	29.944	29.950	29.952	29	39	34	31	42	36	36.3	46	14	.137	.199	.170	.169
10	29.715	29.552	29.347	29.538	36	40	39	38	43	41	40.7	43	23	.186	.208	.212	.202
11	29.682	29.830	29.818	29.777	37	34	31	39	40	33	37.3	44	24	.194	.118	.151	.154
12	29.621	29.542	29.658	29.607	30	35	32	32	39	33	34.7	39	20	.144	.152	.168	.155
13	29.658	29.570	29.543	29.590	31	37	28	33	40	31	34.7	40	20	.151	.181	.119	.150
14	29.889	29.906	29.944	29.913	13	19	15	14	22	16	17.3	31	3	.067	.069	.074	.070
15	30.136	30.119	30.126	30.127	13	26	14	15	29	15	19.7	29	- 1	.056	.106	.071	.078
16	30.073	29.853	29.629	29.852	19	30	24	20	31	25	25.3	32	2	.092	.155	.117	.121
17	29.275	29.310	29.479	29.355	32	34	24	34	36	25	31.7	36	12	.155	.170	.117	.147
18	29.721	29.757	29.867	29.782	12	24	21	13	26	22	20.3	29	1	.063	.106	.107	.092
19	29.941	30.010	30.057	30.003	16	45	24	17	47	26	30.0	50	3	.078	.273	.106	.152
20	30.184	30.202	30.133	30.173	25	36	29	27	39	31	32.3	45	6	.112	.173	.137	.141
21	.....	29.872	29.843	29.858	....	32	22	....	35	35	35.0	38	17	.....	.142	.....	.142
22	29.805	29.824	29.882	29.837	35	35	33	39	42	35	38.5	42	24	.165	.113	.162	.147
23	29.993	29.989	29.912	29.965	29	35	34	31	40	35	35.3	44	18	.137	.139	.183	.153
24	29.858	29.654	29.627	29.713	35	44	39	37	46	41	41.3	47	25	.178	.262	.212	.217
25	29.782	29.887	29.989	29.886	37	34	31	39	37	29	35.0	42	18	.194	.157	.....	.176
26	30.007	29.991	29.821	29.940	25	31	26	26	32	28	28.7	34	13	.123	.162	.117	.134
27	29.521	29.431	29.461	29.471	26	30	27	28	32	28	29.3	32	15	.117	.144	.136	.132
28	29.516	29.530	29.523	29.523	29	33	29	30	36	31	32.3	36	16	.149	.149	.137	.145
29	29.586	29.420	29.448	29.485	28	37	31	30	40	33	34.3	40	13	.130	.181	.151	.154
30	29.460	29.362	29.382	29.401	33	40	37	36	43	39	39.3	43	21	.149	.208	.194	.184
31	29.370	29.483	29.392	29.415	37	50	40	40	54	43	45.7	56	26	.181	.308	.208	.232
Means....	29.764	29.749	29.755	29.752	27.2	34.0	28.5	29.0	36.9	30.4	32.2	56	- 1	.133	.166	.144	.150
April 1	28.990	29.113	29.212	29.105	41	36	36	44	39	39	40.7	48	22	.218	.173	.173	.188
2	29.370	29.506	29.528	29.468	37	42	35	40	45	37	40.7	45	27	.181	.232	.178	.196
3	29.992	29.966	29.858	29.939	32	41	34	35	45	37	39.0	45	19	.142	.245	.157	.181
4	29.553	29.401	29.417	29.457	46	66	39	50	70	41	53.7	70	27	.258	.536	.212	.335
5	29.200	29.244	29.200	29.281	34	42	33	36	45	36	39.0	45	26	.170	.228	.149	.182
6	29.451	29.514	29.485	29.483	30	42	34	32	46	38	38.7	46	19	.144	.215	.144	.168
7	29.501	29.623	29.765	29.630	45	46	35	47	50	38	45.0	51	27	.273	.258	.165	.232
8	29.704	29.686	29.852	29.747	40	42	37	42	45	39	42.0	53	29	.221	.228	.194	.214
9	29.997	29.968	29.813	29.926	34	41	33	37	44	35	38.7	47	21	.157	.218	.162	.179
10	29.660	29.475	29.368	29.501	33	36	35	36	38	37	37.0	38	20	.149	.186	.178	.171
11	29.520	29.609	29.605	29.578	33	39	34	36	44	38	39.3	43	23	.149	.173	.144	.155
12	29.610	29.575	29.478	29.554	35	49	42	45	55	48	47.7	60	21	.139	.269	.189	.199
13	29.727	29.827	29.890	29.815	33	38	35	37	41	36	38.0	48	25	.136	.190	.191	.172
14	29.865	29.785	29.760	29.803	44	51	54	49	57	59	55.0	62	22	.223	.295	.351	.290
15	29.602	29.501	29.487	29.530	53	62	57	58	70	60	62.7	70	45	.336	.449	.426	.404
16	29.417	29.328	29.341	29.362	53	49	44	56	52	47	51.7	69	35	.363	.308	.249	.307
17	29.582	29.667	29.728	29.659	40	49	43	43	56	48	49.0	56	30	.208	.255	.212	.225
18	30.046	30.025	29.994	30.022	36	40	36	41	48	42	43.7	51	28	.147	.143	.134	.141
19	29.964	29.845	29.682	29.830	40	44	40	42	49	43	44.7	52	22	.221	.231	.208	.217
20	29.574	29.285	29.318	29.392	46	60	48	46	65	52	54.3	70	30	.311	.451	.282	.348
21	29.481	29.473	29.474	29.476	42	45	42	47	50	46	47.7	52	33	.202	.234	.215	.217
22	29.349	29.127	29.505	29.327	27	48	36	29	49	38	38.7	50	26	.124	.322	.186	.211
23	29.738	29.837	29.904	29.826	31	35	35	33	41	38	37.3	41	22	.151	.196	.165	.147
24	29.937	29.838	29.808	29.861	33	36	34	37	37	37	37.0	39	22	.136	.199	.157	.164
25	29.957	29.890	29.832	29.893	34	42	40	37	47	43	42.3	50	22	.157	.302	.206	.188
26	29.855	29.604	29.488	29.649	43	55	50	49	65	52	55.3	65	30	.199	.300	.334	.278
27	29.522	29.808	29.941	29.757	37	33	31	39	37	32	36.0	52	22	.194	.136	.162	.164
28	29.996	29.946	29.858	29.933	32	35	34	38	41	37	38.7	43	16	.103	.126	.157	.129
29	29.754	29.671	29.583	29.669	37	47	46	42	51	50	47.7	53	22	.155	.270	.256	.227
30	29.523	29.504	29.433	29.487	50	56	52	54	61	54	56.3	62	38	.308	.383	.362	.351
Means....	29.644	29.621	29.620	29.628	38.4	44.9	39.5	41.7	49.4	42.6	44.6	70	16	.196	.252	.210	.219

the northern and northwestern lakes at Charlotte, New York.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.754	.775	.730	.753	SW..	W....	S.....	4	4	12	5.3	S. 25 W.	10	10	0	.....	.....
.829	.734	.797	.793	S.....	S.....	S.....	4	2	2	2.7	South..	10	10	0	.....	.....
.791	.800	.797	.796	S.....	S.....	S.....	2	2	2	2.0	South..	1	1	0	....	.....
.872	.820	.775	.822	S.....	S.....	S.....	2	2	2	2.0	South.	10	9	0	.....	.....
.876	.792	.890	.853	SE....	SE....	SE....	12	12	4	9.3	S. 45 E.	10	10	10	.....	.....
.890	.782	.883	.852	NW..	W....	W....	4	25	4	10.7	N. 85 W.	10	10	10	.....	.21
.738	.622	.730	.697	W....	W.NW	N.....	25	25	25	20.0	N. 54 W.	10	10	10	.....	.20
.850	.746	.860	.819	N.....	W....	W....	25	25	4	13.0	N. 49 W.	9	7	0	.....	.....
.864	.794	.634	.764	W.NW	W....	SW..	4	4	4	3.7	S. 83 W.	10	10	10	.....	.....
.860	.896	.872	.876	SW..	SW..	SW..	12	2	4	6.0	S. 45 W.	10	10	10	.....	.02
.850	.782	.864	.832	W....	W....	W....	4	4	4	4.0	West...	8	10	10	.....	.01
.797	.845	.823	.822	W....	W.SW	W.SW	25	4	2	10.3	S. 86 W.	10	10	10	.....	.....
.823	.671	.829	.774	E.....	E. NE.	E. NE.	35	25	4	21.0	N. 79 E	10	10	10	.....	.01
.829	.845	.797	.824	N.....	N. NE.	N.....	12	12	12	12.0	N. 7 E..	10	10	10	.....	.05
.791	.659	.791	.747	N.....	N.....	S.....	12	12	4	6.7	North..	10	9	5	.....	.....
.797	.721	.730	.749	S.....	S.....	S.....	12	4	12	9.3	South..	10	10	10	.....	.....
.829	.659	.840	.743	N.....	N.....	N.....	35	35	35	35.0	North..	10	10	10	.....	.19
.784	.610	.784	.726	NW..	NW..	NW..	35	25	25	28.3	N. 45 W.	8	9	10	.....	.10
.791	.823	.816	.810	W....	SW.	SW..	35	4	4	13.7	S. 82 W.	3	8	8	.....	.06
.855	.860	.845	.853	S.....	E.....	E.....	2	12	45	19.0	S. 88 E.	8	10	10	.....	.....
.855	.853	.855	.864	E.....	E.....	NW..	25	4	12	7.3	N. 67 E	10	10	10	.....	.90
.721	.746	.855	.774	W....	W....	W....	12	12	2	8.7	West...	10	10	10	.....	.04
.730	.761	.768	.753	W.NW	W.NW	N.....	25	25	12	18.7	N. 56 W.	10	10	10	.....	.02
.754	.775	.761	.763	W.NW	W.NW	W....	12	12	2	8.7	N. 69 W.	10	10	10	.....	.....
.880	.880	.890	.883	S.....	E.....	E.....	4	4	35	13.3	S. 84 E	10	10	10	.....	.....
.794	.768	.864	.809	SW..	SW..	SW..	25	25	12	20.7	S. 45 W.	10	10	10	.....	.23
.850	.860	.860	.857	W....	W....	W....	45	25	35	35.0	West...	10	10	10	.....	.02
.855	.855	.834	.848	W....	W.SW	W.SW	35	45	45	41.0	S. 74 W.	10	10	10	.....	.42
.791	.816	.791	.799	W....	W....	W....	45	35	45	41.7	West...	9	9	10	.....	.02
.791	.864	.791	.815	W....	W....	W....	4	2	2	2.7	West...	8	10	10	.....	.13
.746	.550	.792	.696	S.....	SW.	S. SW.	4	12	12	9.0	S. 29 W.	10	8	10	.....	.....
.814	.775	.811	.800	.....	.....	.....	....	....	....	6.6	N. 77 W.	9.2	9.4	8.2	.....	2.63
.750	.636	.775	.720	W....	W....	W....	35	25	2	20.7	West...	5	10	0	.....	.....
.775	.775	.800	.783	E.....	NE....	NE....	12	25	60	31.3	N. 50 E.	10	10	10	.....	.....
.811	.712	.860	.794	W....	W....	W....	4	12	25	13.7	West...	10	10	10	.....	.79
.788	.820	.800	.803	W....	SE....	NE....	4	12	25	8.0	N. 68 E.	3	10	10	.....	.02
.896	.896	.887	.993	E.....	NE....	W....	4	4	4	1.3	N. 45 E	10	10	10	.....	.30
.782	.744	.876	.801	W....	W....	W....	2	4	2	2.7	West...	3	10	10	.....	.02
.768	.867	.893	.843	S.....	S.....	S.....	12	12	2	8.7	South..	3	1	0	.....	.....
.794	.512	.836	.714	S.....	S.....	S.....	2	2	2	2.0	South.	0	5	10	.....	.....
.738	.802	.761	.767	S. SE.	SW..	SW..	2	4	25	10.0	S. 41 W.	10	10	10	.....	.04
.797	.804	.816	.806	NW..	NW..	W....	45	25	12	26.3	N. 51 W.	10	4	8	.....	.73
.791	.782	.794	.789	S.....	S.....	S.....	25	12	35	24.0	South.	10	9	10	.....	.03
.705	.836	.807	.783	S.....	S.....	S.....	12	2	2	5.3	South.	10	10	9	.....	.....
.836	.767	.767	.790	S.....	S.....	S.....	12	4	12	9.3	South.	10	10	10	.....	.....
.903	.811	.890	.868	SW..	N. NW	NE....	2	12	12	6.3	N. 7 E.	10	10	5	.....	.29
.864	.876	.876	.872	NE....	NE....	NE....	35	25	4	21.3	N. 45 E.	10	10	4	.....	.....
.557	.557	.811	.642	S. SE..	S. SE..	W....	60	25	25	26.3	S. 5 E.	10	2	10	.....	.....
.628	1.000	.698	.775	W....	W....	NW..	25	35	12	23.0	N. 83 W.	8	8	6	.....	.03
.768	.762	.695	.808	SE....	E.....	N.....	2	4	4	2.0	N. 64 E.	8	10	8	.....	.....
.775	.761	.845	.794	N.....	N.....	N.....	12	12	25	16.3	North.	10	10	10	.....	.....
.754	.794	.872	.807	E.....	E.....	E.....	45	12	25	13.7	East....	10	5	10	.....	.17
.880	.890	.887	.886	E.....	E.....	E.....	25	45	25	31.7	East....	10	10	10	.....	.07
.782	.768	.855	.802	W....	NW..	W.....	25	25	4	16.7	N. 69 W.	10	5	0	.....	.51
.872	.705	.792	.790	SE....	SE....	SE....	25	25	4	18.3	S. 45 E	10	10	10	.....	.04
.705	.698	.761	.721	NW..	N. NW.	N.....	35	35	25	30.3	N. 25 W.	7	10	8	.....	.09
.860	.893	.850	.864	NW..	NE....	NE....	2	25	2	9.0	N. 41 E	10	4	0	.....	.....
.850	.619	.794	.754	S.....	NW..	NW....	2	25	4	9.3	N. 48 W	4	2	0	.....	.....
.868	.797	.872	.846	W....	NE....	SE....	4	25	2	7.3	N. 43 E.	4	0	0	.....	.....
.797	.515	.587	.633	S.....	S.....	S.....	25	2	4	10.3	South.	8	10	10	.....	.....
.789	.764	.820	.791	.....	.....	.....	....	....	....	1.0	N. 1 W.	8.0	7.7	7.1	.....	3.13

Reductions of the monthly meteorological register of the survey of

Date.		Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals				TEMPERATURE—FAHRENHEIT.								VAPOR.			
						Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
		7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.						°	°	°	°	°	°	°						
May	1	29.254	29.254	29.424	29.311	44	40	38	46	46	41	44.3	55	30	.262	.169	.199	.210
	2	29.685	29.850	29.983	29.839	31	34	28	34	40	31	35.0	41	21	.139	.118	.119	.125
	3	30.151	30.182	30.062	30.132	30	35	32	32	39	35	35.3	46	13	.144	.152	.142	.146
	4	30.011	29.787	29.661	29.820	38	49	46	43	56	51	50.0	56	21	.164	.255	.245	.221
	5	29.565	29.539	29.645	29.583	49	59	54	53	63	57	57.7	46	37	.295	.447	.378	.373
	6	29.661	29.616	29.581	29.619	48	48	44	51	49	47	49.0	57	37	.296	.322	.249	.289
	7	29.576	29.554	29.336	29.489	42	43	42	45	46	45	45.3	51	33	.229	.236	.228	.231
	8	29.394	29.284	29.165	29.281	41	41	41	43	42	42	42.3	46	30	.231	.244	.244	.240
	9	29.192	29.254	29.304	29.250	41	43	43	46	46	46	46.0	46	31	.192	.238	.238	.223
	10	29.481	29.433	29.523	29.479	43	49	48	47	57	50	51.3	60	31	.225	.242	.309	.259
	11	29.572	29.600	29.673	29.615	39	50	47	43	35	50	49.3	57	28	.186	.295	.283	.255
	12	29.828	29.795	29.758	29.794	43	49	49	48	57	52	52.3	58	59	.212	.269	.308	.261
	13	29.761	29.508	29.276	29.515	45	48	43	47	52	45	48.0	52	32	.273	.282	.251	.269
	14	29.228	29.285	29.253	29.255	50	41	47	52	57	50	53.0	55	35	.334	.179	.203	.305
	15	29.228	29.215	29.329	29.257	45	48	42	48	53	44	48.3	56	33	.260	.269	.241	.257
	16	29.443	29.517	29.518	29.493	46	48	48	50	56	52	52.7	56	33	.258	.240	.282	.257
	17	29.623	29.577	29.711	29.637	46	50	47	50	56	51	52.3	58	36	.258	.282	.270	.270
	18	29.848	29.834	29.808	29.830	44	47	47	48	57	52	52.3	58	33	.236	.191	.257	.228
	19	29.844	29.777	29.728	29.783	47	50	49	53	56	52	53.7	56	30	.244	.282	.308	.278
	20	29.709	29.655	29.624	29.663	42	48	44	44	52	46	47.3	55	32	.241	.282	.262	.262
	21	29.548	29.363	29.278	29.396	43	46	49	48	50	52	50.0	56	29	.212	.256	.308	.259
	22	29.218	29.119	29.196	29.178	49	53	47	52	56	48	52.0	57	37	.308	.363	.310	.327
	23	29.221	29.978	.....	29.600	44	46	....	47	48	....	47.5	....	....	.249	.284	.....	.266
	24	29.613	29.651	29.678	29.647	45	50	49	50	56	52	52.7	59	33	.234	.282	.308	.275
	25	29.662	29.468	29.422	29.517	52	60	56	58	70	61	63.0	69	38	.309	.385	.383	.359
	26	29.519	29.555	29.633	29.569	43	52	47	44	57	50	50.3	61	39	.264	.322	.283	.290
	27	29.828	29.851	29.801	29.827	47	51	47	52	56	51	53.0	58	30	.257	.308	.270	.278
	28	29.821	29.683	29.576	29.693	47	46	45	51	49	49	49.7	53	34	.270	.271	.247	.263
	29	29.598	29.555	29.597	29.583	48	55	58	52	57	60	56.3	63	38	.282	.407	.456	.382
	30	29.652	29.629	29.647	29.643	52	57	52	57	63	56	58.7	65	40	.322	.386	.335	.348
	31	29.811	29.827	29.819	29.819	43	58	51	47	63	55	55.0	63	36	.225	.416	.321	.321
Means....		29.598	29.587	29.567	29.584	44.1	49.5	44.5	47.8	53.6	49.1	50.1	69	13	.245	.280	.277	.267
June	1	29.854	29.721	29.615	29.730	49	59	50	53	66	53	57.3	68	37	.295	.407	.321	.341
	2	29.484	29.388	29.268	29.380	60	63	63	65	67	67	66.3	67	43	.451	.522	.522	.498
	3	29.236	29.263	29.299	29.266	64	63	58	68	69	63	66.7	71	50	.543	.495	.416	.485
	4	29.529	29.553	29.584	29.555	58	66	62	63	73	65	67.0	73	45	.416	.545	.516	.492
	5	29.774	29.751	29.714	29.746	55	64	62	61	69	65	65.0	72	42	.354	.529	.516	.466
	6	29.555	29.612	29.572	29.580	65	70	71	72	79	77	76.0	86	57	.424	.612	.678	.571
	7	29.661	29.652	29.747	29.687	62	69	56	68	75	60	67.7	77	44	.476	.628	.396	.500
	8	29.782	29.780	29.787	29.783	51	54	56	57	59	60	58.7	61	44	.295	.351	.396	.347
	9	29.837	29.813	29.786	29.812	58	62	64	63	72	68	67.7	72	45	.416	.422	.543	.460
	10	30.107	29.894	29.835	29.945	57	61	56	63	68	60	63.7	70	40	.386	.443	.396	.408
	11	29.874	29.797	29.708	29.973	56	70	65	67	82	71	73.3	83	47	.303	.572	.537	.472
	12	29.699	29.672	29.668	29.680	59	70	67	62	76	71	69.7	77	52	.460	.652	.608	.573
	13	29.751	29.753	29.746	29.750	63	64	63	69	73	68	70.0	76	53	.495	.455	.549	.486
	14	29.816	29.694	29.647	29.719	65	70	74	71	78	78	75.7	85	49	.537	.625	.785	.649
	15	29.620	29.674	29.590	29.628	67	76	70	73	84	74	77.0	84	54	.581	.789	.679	.683
	16	29.652	29.675	29.743	29.690	70	70	66	77	76	69	74.0	80	59	.639	.652	.599	.630
	17	29.805	29.711	29.634	29.717	60	77	75	64	84	74	75.7	85	51	.465	.832	.814	.704
	18	29.668	29.700	29.694	29.687	71	66	56	75	74	61	70.0	79	50	.704	.532	.383	.540
	19	29.985	29.881	29.877	29.914	58	64	63	64	82	67	67.7	78	40	.403	.489	.522	.471
	20	29.917	29.911	29.850	29.893	60	62	58	66	69	62	65.7	77	45	.438	.462	.429	.443
	21	29.977	29.873	29.845	29.898	58	65	59	63	71	63	65.7	72	48	.416	.537	.447	.467
	22	29.867	29.797	29.765	29.810	58	73	67	68	78	72	72.7	80	49	.350	.744	.585	.560
	23	29.811	29.722	29.651	29.728	68	70	65	73	78	70	73.7	80	55	.618	.625	.550	.597
	24	29.693	.....	.....	29.693	67	....	....	74	....	....	74.0	....	....	.568	.....	.....	.568
	25	29.608	29.623	29.625	29.619	64	66	68	67	72	72	70.3	82	52	.556	.559	.631	.582
	26	29.696	29.699	29.660	29.685	63	71	68	68	81	74	74.3	81	56	.509	.624	.604	.579
	27	29.672	29.467	29.472	29.537	71	66	70	77	77	77	77.0	84	59	.678	.564	.639	.627
	28	29.691	29.809	29.830	29.777	63	61	59	69	68	62	66.3	76	52	.495	.445	.460	.466
	29	29.873	29.755	29.646	29.758	55	64	63	61	74	68	67.7	74	41	.354	.462	.509	.442
	30	29.467	29.351	29.462	29.427	69	81	71	79	89	77	81.7	89	56	.574	.948	.678	.733
Means....		29.732	29.689	29.666	29.696	61.5	64.6	61.5	67.7	74.2	68.0	69.9	89	37	.473	.507	.541	.507

the northern and northwestern lakes at Charlotte, New York.

VAPOR.				WIND.							Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.698	.716	.777	.730	E.....	SE....	SE....	4	25	12	13.3	S. 49 E.	3	10	10	.....	.....
.836	.856	.....	.846	SW..	NW..	.....	25	45	....	17.0	N. 74 W.	10	10	10	.....	.....
.834	.850	.855	.846	E.....	E.....	E.....	25	35	25	28.3	East ...	10	10	10	.....	.....
.876	.887	.868	.877	E. SE	W.NW	S.....	12	12	2	0.7	South ..	10	10	10	.....	.12
.761	.792	.864	.806	W.NW	S. SW.	SW..	2	25	4	9.7	S. 29 W.	10	10	10	.....	.....
.850	.712	.887	.816	W	E	E.....	2	25	35	19.3	East ...	10	10	10	.....	.....
.887	.726	.883	.832	E.....	E.NE.	W.NW	60	4	12	17.7	N. 83 E.	10	10	10	.....	.28
.746	.762	.883	.797	W.NW	N	NE ...	2	4	4	2.7	N. 7 E..	8	10	10	.....	.06
.788	.744	.802	.778	E.....	E.....	E.....	2	12	2	5.3	East ...	10	10	10	.....	.....
.811	.750	.824	.795	E.....	E.....	E.....	12	12	25	16.3	East ...	10	10	10	.....	.....
.816	.476	.800	.697	NW..	NW..	S.....	4	25	2	9.3	N. 48 W.	10	8	10	.....	.02
.794	.636	.893	.774	N.....	N.....	N.....	12	12	12	12.0	North .	10	10	10	.....	.....
.800	.732	.685	.739	NE ...	SE....	W	2	12	45	12.0	S. 78 W.	10	10	5	.....	.20
.816	.584	.829	.743	W	W	W	35	25	35	31.7	West...	10	10	8	.....	.01
.648	.665	.823	.712	SW..	SW..	SE....	25	25	2	16.7	S. 43 W.	4	4	0	.....	.20
.850	.893	.872	.872	S	E.....	E.....	2	25	45	23.3	S. 88 E	10	10	10	.....	.....
.792	.802	.872	.822	SE....	W	SW .	2	45	35	24.3	S. 69 W.	10	10	4	.....	.26
.810	.754	.864	.809	W.SW	W	W.SW	45	45	12	33.3	S. 77 W.	4	10	10	.....	.06
.834	.847	.754	.812	S.SW.	SW ..	SE....	4	12	2	5.3	S. 32 W.	0	0	1	.....	.....
.761	.726	.788	.758	S	E.....	E.....	2	25	25	16.7	S. 88 E.	0	10	10	.....	.....
.....	.698	.....	.698	.....	E. SE.	E. NE.	...	35	45	24.7	N. 87 E.	....	10	10	.....	.....
.719	.420	.797	.645	E.....	E. NE.	SE....	35	25	2	20.0	N. 82 E.	10	10	10	.....	.40
.788	.557	.898	.748	E.....	E. SE.	E. SE.	4	12	2	5.7	N. 72 E.	10	10	10	.....	.....
.807	.843	.824	.825	SE....	SE....	SE....	25	4	12	13.7	S. 45 E.	10	10	10	.....	.....
.816	.712	.....	.764	W	W	W	12	45	45	34.0	West...	10	10	6	.....	.....
.876	.896	.768	.847	N.....	N	S	45	12	2	18.3	North ..	2	8	10	.....	.....
.768	.794	.883	.815	E.....	E.NE .	NE ...	35	45	45	39.7	N. 66 E	10	10	10	.....	.....
.890	.705	.788	.794	N.....	W	SW..	25	35	35	19.7	N.89 W.	9	1	1	.....	.20
.782	.732	.800	.771	NW..	NW..	NW..	35	45	4	28.0	N. 45 W.	0	3	2	.....	.....
.705	.750	.816	.757	SW .	SW .	SW .	35	45	12	30.7	S. 45 W.	8	10	10	.....	.....
.732	.738	.750	.740	W	SW ..	SW ..	25	12	2	12.0	S. 74 W.	0	0	0	.....	.....
.796	.734	.827	.783	.....	.....	.....	....	....	....	0.5	S. 72 W.	7.6	8.5	8.0	.....	1.81
.756	.726	.726	.736	S. SE .	W. SW	W	35	45	45	29.3	S. 56 W.	10	10	10	.....	.18
.732	.762	.807	.767	W	W	W	45	60	45	50.0	West...	6	5	0	.....	.01
.698	.684	.712	.698	NW..	NW..	NW..	4	4	4	4.0	N.45 W.	0	2	3	.....	.....
.716	.799	.824	.780	SW .	SW .	N.....	25	12	12	10.0	S. 61 W.	6	10	10	.....	.....
.802	.762	.705	.756	E.....	NW..	W	4	45	4	15.0	N.45 W.	10	8	10	.....	.60
.794	.691	.628	.704	N. NW	SW ..	S.....	35	35	2	13.0	N.82 W.	2	10	0	.....	.09
.847	.716	.719	.761	W	W	W	45	35	2	27.3	West...	10	6	10	.....	.....
.829	.762	.816	.802	E. SE .	NW..	W	25	25	4	3.0	N. 9 E..	10	10	0	.....	.01
.712	.756	.797	.755	W	NE ..	S.....	2	4	2	0.3	N. 45 E.	0	3	0	.....	.02
.705	.811	.807	.774	SW .	E.....	N.....	2	12	12	5.0	N. 45 E.	10	10	10	.....	.....
.705	.597	.628	.643	N. NW	W	SW ..	25	25	35	19.7	S. 89 W.	3	1	0	.....	.73
.557	.620	.563	.580	SW ..	N.....	W	4	4	4	2.3	N.80 W.	0	2	0	.....	.....
.619	.738	.900	.752	E.....	E.....	E.....	35	25	2	20.7	East ...	2	3	6	.....	.....
.638	.634	.703	.658	E.....	E.....	E.....	4	4	25	11.0	East ..	8	10	10	.....	.....
.698	.613	.822	.711	S	S	S	12	4	4	6.7	South ..	10	10	10	.....	.....
.809	.794	.772	.792	S	E.....	NW..	2	4	45	13.3	N.43 W.	10	10	10	.....	.08
.750	.569	.631	.650	N	SW .	W	45	35	45	24.0	N.74 W.	2	2	0	.....	.....
.567	.426	.500	.498	N	N	N	35	12	2	16.3	North ..	0	2	1	.....	.....
.829	.638	.750	.739	S	E.NE .	NE ...	12	72	4	24.0	N. 75 E.	10	10	2	.....	.....
1.000	.731	.727	.819	N.....	S. SW.	N. NW	2	12	12	3.3	N.78 W	7	10	2	.....	.....
.624	.646	.691	.654	W	N. NW	SW ..	25	12	2	12.7	N. 85 W	7	4	1	.....	.01
.775	.926	.811	.837	N.....	N.....	N.....	25	12	12	16.3	North ..	10	10	10	.....	.35
.800	.488	.719	.669	NW ..	NW ..	NW ..	12	25	2	13.0	N. 45 W	10	00	2	.....	.33
.619	.903	.712	.745	E.....	E.....	W	4	2	4	0.7	East ...	10	10	10	.....	.....
.712	.624	.750	.695	W	E.....	E.....	4	25	12	11.0	East ...	7	7	0	.....	.23
.570	.487	.861	.640	S	S	S	12	25	12	16.3	South .	2	7	3	.....	.....
.816	.619	.896	.777	W	W	W	35	35	2	24.0	West...	10	10	0	.....	.08
.450	.468	.712	.550	E.....	NE ...	NE ...	25	25	25	23.3	N. 60 E	0	.....	.....	.....	.....
.577	.722	.716	.672	SE....	SE....	SE....	12	25	25	20.7	S. 45 E.	8	10	2	.....	.....
.738	.713	.867	.773	S	S	S	4	2	2	2.7	South ..	10	10	10	.....	.10
.715	.681	.742	.713	.....	.....	.....	....	....	....	4.6	N. 74 W.	6.3	7.1	4.4	.....	2.82

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°						
May 1	29.254	29.254	29.424	29.311	44	40	38	46	46	41	44.3	55	30	.262	.169	.199	.277
2	29.685	29.850	29.983	29.839	31	34	28	34	40	31	35.0	41	21	.139	.118	.119	.125
3	30.151	30.182	30.062	30.132	30	35	32	32	39	35	35.3	46	13	.144	.152	.142	.146
4	30.011	29.787	29.661	29.820	38	49	46	43	56	51	50.0	56	21	.164	.255	.245	.221
5	29.565	29.539	29.645	29.583	49	59	54	53	63	57	57.7	46	37	.295	.447	.378	.373
6	29.661	29.616	29.581	29.619	48	48	44	51	49	47	49.0	57	37	.296	.322	.249	.289
7	29.576	29.554	29.336	29.489	42	43	42	45	46	45	45.3	51	33	.228	.238	.228	.231
8	29.394	29.284	29.165	29.281	41	41	41	43	42	42	42.3	46	30	.231	.244	.244	.240
9	29.192	29.254	29.304	29.250	41	43	43	46	46	46	46.0	46	31	.192	.236	.238	.223
10	29.481	29.433	29.523	29.479	43	49	48	47	57	50	51.3	60	31	.225	.242	.309	.259
11	29.572	29.600	29.673	29.615	39	50	47	43	35	50	49.3	57	28	.186	.295	.283	.255
12	29.828	29.795	29.758	29.794	43	49	49	48	57	52	52.3	58	59	.212	.269	.308	.261
13	29.761	29.508	29.276	29.515	45	48	43	47	52	45	48.0	52	32	.273	.262	.251	.269
14	29.228	29.285	29.253	29.255	50	41	47	52	57	50	53.0	55	35	.334	.179	.283	.265
15	29.228	29.215	29.329	29.257	45	48	42	48	53	44	48.3	56	33	.260	.269	.241	.257
16	29.443	29.517	29.518	29.493	46	48	48	50	56	52	52.7	56	33	.258	.230	.282	.257
17	29.623	29.577	29.711	29.637	46	50	47	50	56	51	52.3	58	36	.256	.282	.270	.270
18	29.848	29.834	29.808	29.830	44	47	47	48	57	52	52.3	58	33	.236	.191	.257	.228
19	29.844	29.777	29.728	29.783	47	50	49	53	56	52	53.7	56	30	.244	.282	.308	.278
20	29.709	29.635	29.624	29.663	42	48	44	44	52	46	47.3	55	32	.241	.282	.262	.262
21	29.548	29.363	29.278	29.396	43	46	49	48	50	52	50.0	56	29	.212	.258	.308	.259
22	29.218	29.119	29.196	29.178	49	53	47	52	56	48	52.0	57	37	.308	.363	.310	.327
23	29.221	29.978	.....	29.600	44	46	....	47	48	....	47.5	....	....	.249	.284	....	.366
24	29.613	29.651	29.678	29.647	45	50	49	50	56	52	52.7	59	33	.234	.282	.308	.275
25	29.662	29.468	29.422	29.517	52	60	56	58	70	61	63.0	69	38	.309	.385	.383	.359
26	29.519	29.555	29.633	29.569	43	52	47	44	57	50	50.3	61	39	.264	.322	.283	.290
27	29.828	29.851	29.801	29.827	47	51	47	52	56	51	53.0	58	30	.257	.308	.270	.278
28	29.821	29.683	29.576	29.693	47	46	45	51	49	49	49.7	53	34	.270	.271	.247	.263
29	29.598	29.555	29.597	29.583	48	55	58	52	57	60	56.3	63	38	.282	.407	.456	.382
30	29.652	29.629	29.647	29.643	52	57	52	57	63	56	58.7	65	40	.322	.386	.335	.348
31	29.811	29.827	29.819	29.819	43	58	51	47	63	55	55.0	63	36	.225	.416	.321	.321
Means....	29.598	29.587	29.567	29.584	44.1	49.5	44.5	47.8	53.6	49.1	50.1	69	13	.245	.280	.277	.267
June 1	29.854	29.721	29.615	29.730	49	59	50	53	66	53	57.3	68	37	.295	.407	.321	.341
2	29.484	29.388	29.268	29.380	60	63	63	65	67	67	66.3	67	43	.451	.522	.522	.498
3	29.236	29.263	29.299	29.266	64	63	58	68	69	63	66.7	71	50	.543	.495	.416	.485
4	29.529	29.553	29.584	29.555	58	66	62	63	73	65	67.0	73	45	.416	.545	.516	.492
5	29.774	29.751	29.714	29.746	55	64	62	61	69	65	65.0	72	42	.354	.529	.516	.466
6	29.555	29.612	29.572	29.580	65	70	71	72	79	77	76.0	86	57	.424	.612	.678	.571
7	29.661	29.652	29.747	29.687	62	69	56	68	75	60	67.7	77	44	.476	.628	.396	.500
8	29.782	29.780	29.787	29.783	51	54	56	57	59	60	58.7	61	44	.295	.351	.396	.347
9	29.837	29.813	29.786	29.812	58	62	64	63	72	68	67.7	72	45	.416	.422	.543	.460
10	30.107	29.894	29.815	29.945	57	61	56	63	68	60	63.7	70	40	.386	.443	.396	.408
11	29.874	29.797	29.708	29.973	56	70	65	67	82	71	73.3	83	47	.303	.572	.537	.472
12	29.699	29.672	29.668	29.680	59	70	67	62	76	71	69.7	77	52	.460	.652	.608	.573
13	29.751	29.753	29.746	29.750	63	64	63	69	73	68	70.0	76	53	.495	.455	.509	.486
14	29.816	29.694	29.647	29.719	65	70	74	71	78	78	75.7	85	49	.537	.625	.785	.649
15	29.620	29.674	29.590	29.628	67	76	70	73	84	74	77.0	84	54	.581	.789	.679	.683
16	29.652	29.675	29.743	29.690	70	70	66	77	76	69	74.0	80	59	.639	.652	.569	.620
17	29.805	29.711	29.634	29.717	60	77	75	64	84	74	75.7	85	51	.465	.832	.814	.704
18	29.668	29.700	29.694	29.687	71	66	56	75	74	61	70.0	79	50	.704	.532	.383	.540
19	29.985	29.881	29.877	29.914	58	64	63	64	92	67	67.7	78	40	.403	.489	.522	.471
20	29.917	29.911	29.850	29.893	60	62	58	66	69	62	65.7	77	45	.438	.462	.429	.443
21	29.977	29.873	29.845	29.898	58	65	59	63	71	63	65.7	72	48	.416	.537	.447	.467
22	29.867	29.797	29.765	29.810	58	73	67	68	78	72	72.7	80	49	.350	.744	.595	.563
23	29.811	29.722	29.651	29.728	68	70	65	73	78	70	73.7	80	55	.618	.625	.550	.597
24	29.693	.....	.....	29.693	67	....	....	74	....	....	74.0	....	....	.568	....	....	.568
25	29.608	29.623	29.625	29.619	64	66	68	67	72	72	70.3	82	52	.556	.559	.631	.582
26	29.696	29.699	29.660	29.685	63	71	68	68	81	74	74.3	81	56	.509	.624	.604	.579
27	29.672	29.467	29.472	29.537	71	68	70	77	77	77	77.0	84	59	.678	.564	.629	.627
28	29.691	29.809	29.830	29.777	63	61	59	69	68	62	66.3	76	52	.495	.445	.460	.466
29	29.873	29.755	29.646	29.758	55	64	68	61	74	68	67.7	74	41	.354	.462	.509	.442
30	29.467	29.351	29.462	29.427	69	81	71	79	89	77	81.7	89	56	.574	.948	.678	.733
Means....	29.732	29.689	29.666	29.696	61.5	64.6	61.5	67.7	74.2	68.0	69.9	89	37	.473	.507	.541	.528

the northern and northwestern lakes at Charlotte, New York.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.843	.543	.738	.708	N.....	W	NW...	35	35	25	24.7	N.45 W.	10	10	4	.....	.48
.712	.476	.685	.624	W	W	W	35	45	25	35.0	West...	6	4	4	.....	.85
.794	.636	.698	.709	NW...	NE ...	NE ...	4	25	25	16.7	N. 40 E.	6	3	0	.....	.....
.587	.569	.651	.603	SE....	SE ...	SE....	35	45	45	41.7	S. 45 W.	10	10	10	.....	.....
.733	.776	.812	.774	S	S	S	45	4	12	20.5	South ..	10	10	10	.....	.03
.790	.926	.772	.829	S	N	S	4	4	4	1.3	South ..	10	10	10	.....	.08
.762	.767	.762	.764	S. SW.	W.NW	W.NW	4	4	2	2.7	S. 80 W.	6	10	10	.....	.44
.833	.914	.914	.887	N	N	N	25	45	60	43.3	North ..	10	10	10	.....	.05
.617	.767	.767	.717	W	W	W	35	12	12	19.7	West...	10	10	10	.....	.12
.698	.521	.856	.692	NW...	NW...	NW...	12	25	2	13.0	N. 45 W.	7	7	2	.....	.06
.669	.681	.786	.712	W	W	W	4	12	2	6.0	West...	2	3	0	.....	.....
.631	.620	.794	.682	W	W. SW	W. SW	25	12	12	16.0	S. 79 W.	1	0	0	.....	.....
.847	.727	.840	.805	SW ...	E	SW ...	12	12	2	3.3	S. 12 E.	10	10	10	.....	.....
.861	.554	.786	.734	SW ...	W	SW ...	25	35	12	22.3	S. 67 W.	10	8	10	.....	.15
.777	.667	.836	.760	S W...	SW ...	SW ...	4	12	12	9.3	S. 45 W.	10	10	10	.....	.15
.716	.512	.727	.652	NW...	NW ...	NW ...	12	25	12	16.3	N. 45 W.	7	3	6	.....	.06
.716	.627	.722	.688	N. NW	W.NW	W	4	25	4	10.3	N. 65 W.	7	7	10	.....	.....
.704	.411	.660	.592	N	W	W	25	25	4	13.0	N. 49 W.	10	10	1	.....	.....
.606	.627	.794	.676	W	W	W	12	4	2	6.0	West...	0	10	10	.....	.....
.836	.727	.843	.802	NE ...	N. NE.	W	12	4	2	5.0	N. 33 E.	10	10	2	.....	.32
.631	.716	.794	.714	E	E	E	2	25	25	17.3	East ...	7	10	10	.....	.....
.794	.809	.925	.843	S	N	S	12	4	2	3.3	North ..	10	10	10	.....	.48
.772	.850	.....	.811	SW ...	SW ...	.....	4	25	....	14.3	S. 45 W.	10	10	....	.....	.40
.646	.627	.794	.689	N	N	S	12	4	2	4.7	North ..	3	2	10	.....	.11
.641	.525	.713	.626	S	S	W	2	45	35	19.7	S. 37 W.	2	10	10	.....	.....
.918	.692	.786	.799	SW ...	W.SW	NW...	4	25	4	10.0	S. 71 W.	10	3	0	.....	.02
.660	.687	.722	.690	N	N	N	4	4	2	3.3	North ..	2	7	7	.....	.....
.722	.781	.710	.738	N	E	E	2	35	12	16.0	N. 87 E.	10	10	10	.....	.....
.727	.874	.880	.827	SW ...	W.NW	W	2	4	12	5.7	N. 80 W.	10	10	0	.....	.14
.692	.670	.747	.703	W	W	W	12	4	25	13.7	West...	5	10	6	.....	.....
.698	.723	.743	.721	NW...	NW...	W	25	12	4	13.3	N. 49 W.	10	3	0	.....	.04
.730	.677	.775	.728	.....	.....	.....	....	...	....	5.1	N. 81 W.	7.4	7.7	6.7	.....	3.98
.733	.636	.798	.722	SW ...	SW ...	NW...	4	35	25	15.3	S. 78 W.	10	10	10	.....	.....
.731	.790	.790	.770	SE....	SE....	S	2	25	45	22.3	S. 17 E.	10	10	6	.....	.....
.793	.700	.723	.739	SW ...	SW ...	SW ...	12	45	4	20.3	S. 45 W.	3	6	10	.....	.23
.723	.672	.836	.744	W	W	W	12	25	2	13.0	West...	2	2	1	.....	.....
.659	.747	.836	.747	W.NW	W.NW	SW ...	4	4	2	3.0	N. 79 W.	1	1	8	.....	.....
.668	.618	.731	.672	S	N	N	12	2	4	2.0	South ..	2	4	0	.....	.....
.695	.724	.765	.728	N	N	NE ...	2	4	12	5.7	N. 29 E.	2	10	10	.....	.....
.634	.703	.765	.701	NE ...	NE ...	E	25	25	2	17.3	N. 46 E.	10	10	5	.....	.....
.723	.539	.793	.685	NE ...	NE ...	NW...	4	12	2	5.3	N. 37 E.	2	2	0	.....	.....
.670	.647	.765	.694	E	NE ...	N	2	25	2	9.3	N. 45 E.	3	10	10	.....	.....
.459	.524	.708	.564	S	S	S	35	25	25	28.3	South ..	6	7	0	.....	.....
.828	.727	.802	.786	S	S	S	25	4	12	13.7	South ..	10	10	6	.....	.....
.700	.582	.743	.675	W	NW...	N. NE.	4	35	2	12.7	N. 46 W.	0	10	0	.....	.11
.708	.653	.819	.793	S	S	S	2	12	2	5.3	South ..	2	4	10	.....	.....
.716	.677	.810	.734	S	S	S	12	4	2	6.0	South ..	9	10	10	.....	.....
.689	.727	.846	.754	N	N	N	2	12	2	5.3	North ..	10	10	0	.....	.....
.780	.714	.822	.772	NE ...	E	S	4	25	2	9.0	N. 88 E.	10	5	2	.....	.22
.812	.634	.713	.720	SW ...	W	NE ...	4	25	2	8.7	S. 87 W.	10	6	1	.....	.....
.675	.624	.790	.696	N	NW...	W	2	25	2	9.3	N. 45 W.	0	1	0	.....	.....
.685	.653	.772	.703	S	NE ...	NE ...	2	35	12	15.3	N. 47 E.	10	10	10	.....	.....
.723	.708	.776	.736	NE ...	NE ...	SW ...	12	25	2	11.3	N. 45 E.	4	2	0	.....	.25
.511	.776	.758	.682	SW ...	NE ...	SE....	2	25	4	8.0	N. 55 E.	8	2	2	.....	.....
.761	.653	.751	.722	N. NE.	NE ...	S	12	12	2	7.3	N. 37 E.	6	10	2	.....	.....
.677	.....	.....	.677	S	.....	.....	2	...	....	0.7	South ..	0	.....	....	.....	.....
.841	.712	.804	.786	E	E	E	2	12	12	8.7	East ...	1	10	2	.....	.....
.743	.590	.720	.684	S	S	S	25	4	12	13.7	South ..	8	10	4	.....	.....
.731	.608	.689	.673	S	E	S	4	12	2	4.7	S. 61 E.	3	5	9	.....	.....
.700	.647	.828	.725	NW...	NW...	E	25	35	2	19.7	N. 44 W.	3	2	0	.....	.03
.659	.551	.743	.651	SW ...	N	S	4	4	2	1.0	S. 75 W.	0	0	0	.....	.....
.580	.694	.731	.668	S	S	NW...	35	45	4	25.7	S. 2 W.	6	10	10	.....	.....
.700	.698	.773	.713	.....	.....	.....	....	....	....	1.5	S. 2 W..	5.2	6.3	4.3	.....	.84

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.									VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.				Maximum.	Minimum.	Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.			7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Sept. 1	29.509	29.557	29.690	29.585	58	58	52	63	60	55	59.3	65	45	.416	.456	.349	.407
2	29.805	29.831	29.759	29.798	53	60	60	57	69	63	63.0	68	44	.351	.398	.492	.410
3	29.705	29.639	29.601	29.648	59	70	63	64	81	70	71.7	82	47	.433	.565	.482	.500
4	29.768	29.795	29.757	29.773	54	66	59	59	74	63	65.3	75	46	.351	.532	.447	.443
5	29.715	29.674	29.563	29.651	52	74	70	57	83	73	71.0	84	43	.322	.718	.493	.578
6	29.540	29.531	29.725	29.599	67	73	57	74	84	64	74.0	85	53	.568	.663	.373	.535
7	29.925	30.071	30.002	29.999	54	62	56	60	72	65	65.7	72	45	.338	.422	.330	.360
8	30.050	29.983	29.904	29.979	55	65	65	62	72	68	67.3	73	39	.340	.524	.577	.480
9	29.764	29.593	29.580	29.646	61	75	69	65	87	74	75.3	86	52	.483	.705	.641	.610
10	29.715	29.757	29.793	29.755	54	54	54	57	60	54	57.0	74	43	.378	.338	.418	.378
11	29.873	29.827	29.705	29.802	42	67	52	46	77	57	60.0	77	32	.215	.527	.329	.355
12	29.700	29.659	29.618	29.659	49	67	63	55	81	67	67.7	82	42	.269	.474	.522	.422
13	29.511	29.495	29.622	29.543	60	68	53	66	75	58	66.3	80	47	.438	.591	.336	.455
14	29.898	30.000	30.060	29.986	47	56	49	52	62	51	55.0	62	40	.257	.369	.321	.316
15	30.018	29.963	29.887	29.623	42	65	57	48	75	63	62.0	78	32	.189	.481	.396	.353
16	29.897	29.822	29.828	29.849	61	73	70	67	80	74	73.7	80	50	.457	.717	.479	.618
17	29.931	29.870	29.890	29.897	68	81	74	73	91	77	80.3	91	57	.618	.921	.799	.779
18	29.775	29.748	29.775	29.766	72	81	73	75	92	79	82.0	92	62	.744	.948	.739	.794
19	29.069	29.940	29.809	29.906	62	68	63	66	76	66	69.3	78	52	.502	.577	.536	.538
20	29.685	29.611	29.779	29.692	70	74	59	76	83	63	74.0	90	53	.652	.718	.447	.606
21	29.926	29.927	29.864	29.906	51	62	52	56	67	57	60.0	68	43	.308	.489	.322	.373
22	29.829	.....	29.841	29.835	51	....	64	55	....	69	62.0	77	38	.321	....	.529	.425
23	30.190	30.207	30.133	30.177	47	54	42	51	60	46	52.3	66	36	.270	.338	.215	.274
24	30.085	29.967	29.812	29.955	43	65	58	49	77	65	63.7	77	28	.199	.457	.389	.348
25	29.549	29.678	.....	29.614	58	59	...	63	67	....	65.0	...	...	.403	.393	...	.398
26	29.960	29.892	29.860	29.904	47	50	43	51	51	47	49.7	66	36	.270	.348	.235	.284
27	29.859	29.734	29.733	29.775	37	58	52	40	65	54	53.0	65	26	.181	.369	.362	.311
28	29.688	29.577	29.572	29.612	45	71	60	48	82	62	64.0	82	38	.260	.610	.491	.454
29	29.416	29.522	29.706	29.548	60	56	43	68	58	49	58.3	71	37	.411	.422	.199	.344
30	29.954	29.880	29.859	29.898	37	43	38	42	47	40	43.0	47	30	.155	.225	.203	.194
Means....	29.807	29.785	29.786	29.779	53.9	64.7	57.6	58.8	72.7	61.8	64.3	92	26	.372	.527	.442	.440
Oct. 1	29.815	29.676	29.555	29.682	34	59	49	38	67	53	52.7	69	28	.144	.393	.285	.274
2	29.445	29.281	29.389	29.372	48	58	57	56	66	63	61.7	71	37	.230	.376	.386	.331
3	29.678	29.688	29.674	29.680	47	48	38	52	52	42	48.7	61	31	.257	.282	.177	.239
4	29.872	29.766	29.745	29.794	32	54	50	35	63	53	50.3	63	20	.142	.288	.321	.250
5	29.373	29.404	29.633	29.470	50	55	46	54	60	51	54.7	61	37	.308	.367	.238	.311
6	30.080	30.042	30.030	30.034	41	44	44	47	54	51	50.7	54	34	.179	.157	.196	.177
7	30.282	30.240	.....	30.261	41	44	....	46	54	....	50.0	.....	.....	.192	.157	....	.175
8	30.187	30.029	29.900	30.039	33	54	47	37	64	51	50.7	66	20	.136	.265	.270	.224
9	29.736	29.429	29.365	29.510	42	57	53	45	62	57	54.7	62	32	.228	.399	.350	.326
10	29.250	29.197	29.213	29.220	50	55	51	55	60	54	56.3	60	42	.295	.367	.335	.332
11	29.311	29.380	29.413	29.368	48	54	52	51	59	54	54.7	59	39	.296	.351	.362	.336
12	29.491	29.548	29.644	29.561	48	47	43	51	48	46	48.3	55	34	.296	.310	.258	.288
13	29.682	29.680	29.658	29.673	42	52	48	43	55	52	50.0	55	31	.254	.349	.262	.288
14	29.754	29.772	29.651	29.726	40	54	49	42	60	51	51.0	61	29	.221	.338	.321	.293
15	29.645	29.687	29.713	29.682	49	53	48	53	60	50	54.3	60	37	.295	.310	.309	.305
16	29.906	29.840	29.810	29.852	38	67	55	41	76	59	58.7	76	28	.190	.542	.289	.340
17	29.762	29.702	29.543	29.669	53	69	63	58	80	69	69.0	80	46	.336	.561	.495	.464
18	29.621	29.622	29.646	29.630	60	68	59	63	80	64	69.0	80	52	.478	.524	.450	.484
19	29.705	29.870	29.785	29.787	52	66	60	57	75	64	65.3	80	44	.322	.519	.465	.435
20	29.894	29.893	29.857	29.878	55	67	64	57	74	67	66.0	75	45	.407	.568	.556	.510
21	29.867	29.692	29.722	29.760	59	68	59	63	79	65	69.0	78	51	.417	.537	.490	.481
22	29.765	29.834	29.868	29.822	54	48	43	57	53	48	52.7	67	36	.378	.269	.212	.286
23	30.071	30.147	30.097	30.105	38	43	33	43	51	37	43.7	51	26	.164	.173	.136	.158
24	30.188	30.199	30.086	30.158	32	50	38	33	57	41	43.7	60	21	.168	.268	.190	.209
25	30.178	30.132	30.086	30.132	31	53	38	33	61	41	45.0	61	21	.151	.297	.190	.213
26	30.061	30.018	29.986	30.022	29	49	38	32	57	41	43.3	59	20	.126	.242	.190	.186
27	30.092	.....	30.010	30.034	22	....	47	35	....	51	43.0	62	22	.....	.....	.270	.270
28	30.029	29.935	29.924	29.963	37	53	48	40	59	59	52.7	59	27	.181	.321	.190	.231
29	29.777	29.647	29.603	29.676	48	52	50	52	56	54	54.0	56	39	.292	.315	.308	.305
30	29.603	29.535	29.498	29.545	47	51	49	50	56	52	52.7	56	39	.283	.308	.308	.300
31	29.576	29.718	29.771	29.688	46	46	42	49	50	47	48.7	53	37	.271	.258	.302	.244
Means....	29.795	29.753	29.729	29.768	43.4	54.6	48.7	48.0	61.6	52.9	53.7	80	20	.255	.349	.301	.300

the northern and northwestern lakes at Charlotte, New York.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.740	.612	.695	.683	N	N	S	4	4	2	2.0	North	5	3	8	.....	.04
.624	.511	.796	.644	SW	N	S	4	12	2	4.3	N. 12 W.	3	3	1	.....	.....
.695	.605	.824	.708	SW	NW	SE	4	4	2	1.7	S. 74 W.	3	3	1	.....	.....
.668	.711	.900	.760	S	NE	N	12	4	4	2.0	S. 28 E	6	10	10	.....	.....
.828	.668	.796	.764	NE	E	E	25	25	4	16.7	N. 69 E	10	10	7	.....	.43
.776	.865	.804	.815	S	W	SW	4	4	4	2.3	S. 80 W.	3	10	2	.....	.....
.685	.776	.723	.728	SW	SW	W	12	2	4	5.7	S. 55 W.	3	10	0	.....	.48
.809	.663	.786	.753	SW	SW	S	4	4	2	3.0	S. 39 W.	3	8	5	.....	.11
.819	.880	.812	.837	NE	N.NE	S	12	25	2	11.7	N. 32 E	10	10	0	.....	.36
.743	.819	.796	.786	W	SW	S	2	2	2	1.7	S. 45 W.	0	10	10	.....	.11
.647	.....	.819	.733	SW	.....	SW	25	....	25	16.7	S. 45 W.	6	....	10	.....	.....
.838	.695	.772	.768	NW	NW	NW	12	4	4	6.3	N. 45 W.	10	9	2	.....	.22
.659	.511	.692	.621	NE	NE	S	35	4	2	12.7	N. 47 E	0	0	0	.....	.....
.731	.689	.790	.737	NE	NE	NE	4	12	25	13.7	N. 45 E	0	3	0	.....	.....
.636	.613	.810	.686	SE	SE	NW	12	4	4	5.7	S. 60 E	2	10	10	.....	.....
.727	.504	.723	.651	NW	N	N	12	35	4	16.0	N. 10 W.	4	2	0	.....	.....
.568	.681	.....	.625	N.NW	NE	S	4	4	2	1.7	N. 15 E	3	1	10	.....	.....
.718	.812	.780	.770	N	N	N	2	4	2	2.7	North	7	6	10	.....	.....
.723	.810	.890	.808	NE	N. NE	N	12	12	25	15.3	N. 17 E	5	4	10	.....	.....
.836	.804	.790	.810	N.NE	N.NW	NW	12	12	12	10.7	N. 15 W.	10	5	0	.....	.03
.663	.665	.793	.707	W	E	N	25	2	4	8.0	N. 79 W.	0	10	4	.....	.....
.793	.608	.790	.730	N.NW	N	S	25	4	2	9.0	N. 21 W.	4	3	0	.....	.54
.717	.507	.819	.691	SW	N	S	2	4	12	3.3	S. 8 W.	3	6	0	.....	.....
.677	.622	.744	.681	SW	W	S	4	12	2	5.0	S. 72 W.	0	10	0	.....	.....
.768	.744	.854	.789	SW	N. NE	N	35	4	2	10.3	S. 50 W.	10	10	10	.....	.....
.848	.697	.850	.798	NE	NE	NE	25	25	2	17.3	N. 45 E	10	1	10	.....	.12
.675	.573	.708	.652	S	S	S	2	4	2	2.7	South	3	4	2	.....	.....
.747	.637	.826	.737	S	S	S	25	45	35	35.0	South	3	7	8	.....	.....
.712	.603	.731	.682	N.NW	W	NW	35	25	25	25.3	N. 48 W.	3	6	0	.....	.....
.698	.551	.670	.640	N	N	S	12	2	4	3.3	North	3	1	3	.....	.....
.692	.548	.658	.633	S	S	S	4	12	25	13.7	South	3	8	7	.....	.....
.726	.666	.782	.723	.....	.....	.....	....	....	....	1.2	N. 17 W.	4.3	6.1	4.5	.....	2.44
.647	.734	.743	.708	S	S	S	35	4	2	13.7	South	7	10	6	.....	.....
.743	.822	.708	.758	S	N	W	2	2	2	0.7	West	10	4	2	.....	.04
.783	.663	.831	.759	N	N	N	12	12	4	9.3	North	10	2	0	.....	.03
.735	.590	.618	.648	S	N	S W	2	4	4	1.0	S. 75 W.	0	1	2	.....	.....
.6 9	.787	.672	.689	SW	SW	S	12	12	2	8.7	S. 43 W	3	3	2	.....	.....
.644	.784	.689	.706	S.S W	W.NW	S	2	12	2	3.7	N. 86 W.	2	2	2	.....	.....
.708	.718	.724	.717	SW	NW	S	4	2	2	1.7	S. 53 W.	4	2	0	.....	.....
.681	.691	.724	.699	S	S	S	2	4	2	2.7	South	0	3	0	.....	.....
.727	.691	.817	.745	S	NE	E	2	25	2	8.3	N. 52 E	0	3	0	.....	.....
.724	.618	1.000	.781	W.NW	NW	SW	12	25	4	12.3	N. 58 W.	10	7	4	.....	.....
.716	.750	.731	.732	NE	NE	N	25	4	2	10.0	N. 42 E	0	4	0	.....	.....
.703	.538	.629	.623	S	S	S	2	12	4	6.0	South	0	2	3	.....	.....
.774	.689	.724	.729	S	N	W	12	12	2	0.7	West	10	8	10	.....	.24
.799	.644	.783	.742	N	N	N	11	12	2	8.7	North	7	3	2	.....	.....
.772	.569	.677	.673	NW	N	E.N E	2	12	45	17.0	N. 53 E	10	6	6	.....	.....
.802	.807	.804	.804	NE	S	N	25	35	35	8.3	N. 45 E	10	10	3	.....	.01
.802	.590	.804	.732	N	NW	S	25	25	2	14.7	N. 24 W.	8	1	4	.....	.....
.497	.488	.734	.573	S.S W	SW	S	12	45	4	19.7	S. 38 W.	10	3	10	.....	.....
.685	.668	.735	.696	W	W	W	12	25	4	13.7	West	3	10	2	.....	.....
.680	.716	.675	.690	W	W	W	2	4	2	2.7	West	10	5	4	.....	.....
.636	.618	.....	.627	W	NW	.....	2	12	....	4.3	N. 51 W.	3	7	....	.....	.....
.703	.697	.856	.752	S	NW	E	2	12	2	3.0	N. 45 W.	8	9	10	.....	.....
.780	.708	.807	.765	SE	NE	E	4	12	2	5.0	N. 68 E.	2	0	2	.....	.....
.751	.569	.613	.644	SW	W	W.NW	5	25	25	17.0	N. 83 W.	10	2	0	.....	.....
.772	.524	.796	.697	NW	NW	NW	2	4	2	2.6	N. 45 W.	0	0	0	.....	.....
.713	.600	.629	.647	S	N	S	2	12	2	2.7	North	1	0	0	.....	.....
.704	.648	.782	.711	S	NE	N	2	25	2	8.3	N. 45 W.	10	4	10	.....	.....
.720	.714	.653	.696	S	S	N	25	25	25	8.3	South	9	10	0	.....	.....
.618	.417	.884	.640	NW	N	W	2	25	4	9.0	N. 11 W.	7	3	10	.....	.....
.660	.479	.733	.624	S	N	S	4	45	4	12.3	North	9	4	0	.....	.11
.653	.493	.731	.626	S	S	S	12	2	2	5.3	South	5	10	10	.....	.....
.707	.646	.743	.698	.....	.....	.....	....	....	....	2.0	N. 41 W.	5.7	4.5	3.5	.....	.43

Reductions of the monthly meteorological register of the surgery of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°		°	°	°						
Nov. 1	29.807	29.466	29.340	29.558	37	54	49	41	64	55	53.3	62	27	.168	.285	.269	.241
2	29.232	29.335	29.548	29.372	53	49	43	58	57	48	54.3	69	36	.336	.242	.212	.263
3	29.526	29.270	29.026	29.271	40	47	52	45	55	57	52.3	58	31	.182	.217	.322	.240
4	29.449	29.658	29.818	29.642	38	41	34	44	48	37	43.0	61	26	.151	.166	.157	.158
5	30.031	29.902	29.807	29.913	29	43	36	32	50	41	41.0	50	19	.126	.186	.147	.153
6	29.982	30.017	30.041	30.013	30	33	29	35	37	32	34.7	43	19	.109	.136	.126	.124
7	29.923	29.744	29.688	29.785	29	38	31	31	42	33	35.3	45	18	.137	.177	.151	.155
8	29.550	.....	29.440	29.495	36	...	52	40	....	59	49.5	67	17	.160	....	.296	.228
9	29.392	29.526	29.603	29.507	54	56	46	62	64	50	58.7	66	37	.312	.343	.256	.304
10	29.716	29.632	29.661	29.670	42	51	47	45	58	51	51.3	57	32	.228	.282	.270	.260
11	29.735	29.690	29.663	29.703	36	36	32	38	40	35	37.7	51	23	.186	.160	.142	.163
12	29.692	29.688	29.673	29.684	31	33	33	34	37	35	35.3	39	18	.139	.136	.162	.146
13	29.636	29.583	29.546	29.588	28	31	30	30	35	30	31.7	32	18	.130	.128	.167	.142
14	26.215	29.269	29.308	29.264	30	39	32	34	44	37	38.3	45	18	.121	.173	.116	.137
15	29.886	29.927	29.751	29.855	26	32	29	30	37	32	33 0	37	16	.095	.116	.126	.112
16	29.377	29.600	29.751	29.576	37	34	30	41	36	32	36.3	41	19	.168	.170	.144	.161
17	29.603	29.427	29.553	29.528	28	37	30	31	41	31	34.3	40	19	.119	.162	.135	.147
18	29.823	29.747	29.720	29.763	18	22	19	20	26	21	22.3	30	7	.076	.072	.085	.078
19	29.993	29.926	29.751	29.890	18	26	26	20	30	28	26.0	29	8	.076	.095	.117	.096
20	29.763	29.664	29.804	29.744	31	38	39	35	42	42	39.7	40	17	.128	.177	.199	.168
21	29.940	29.866	29.845	29.884	33	38	32	36	41	34	37.0	42	21	.149	.190	.155	.165
22	29.790	29.731	29.751	29.757	38	46	44	40	51	47	46.0	50	18	.203	.245	.249	.232
23	29.774	.....	29.795	29.785	43	....	46	46	....	49	47.5	56	33	.238	....	.271	.255
24	29.814	29.685	29.697	29.732	40	42	53	42	57	56	51.7	56	30	.221	.071	.363	.218
25	29.718	.....	29.465	29.592	49	...	52	52	....	57	54.5	56	40	.318	....	.322	.315
26	29.556	29.613	29.924	29.698	42	50	34	45	54	38	45.7	56	24	.228	.318	.144	.230
27	29.934	29.764	29.710	29.803	34	37	36	38	42	40	40.0	42	25	.144	.155	.169	.156
28	29.750	29.696	29.727	29.724	37	41	38	40	45	41	42.0	45	27	.181	.205	.190	.192
29	29.514	29.167	29.832	29.504	40	43	39	42	45	43	43.3	44	28	.221	.251	.186	.219
30	29.433	29.621	29.626	29.560	18	15	13	20	17	15	17.3	44	4	.076	.063	.056	.065
Means....	29.685	29.645	29.663	29.661	34.8	39.0	36.9	38.2	44.3	40.2	41.1	69	4	.177	.190	.193	.186
Dec. 1	30.066	29.924	29.819	29.936	17	24	26	19	27	29	25.0	29	5	.071	.095	.106	.091
2	29.694	29.648	29.740	29.691	24	33	32	27	37	36	33.5	36	14	.095	.136	.129	.120
3	29.818	29.578	29.488	29.628	30	34	31	33	37	33	34.3	39	19	.132	.157	.151	.147
4	29.631	29.402	29.453	29.495	12	22	19	13	24	20	19.0	33	-1	.063	.085	.092	.080
5	29.429	.....	29.616	29.523	23	...	28	25	....	30	27.5	35	8	.100	....	.130	.115
6	29.448	29.075	28.894	29.139	34	35	45	37	38	50	41.7	50	25	.157	.165	.230	.185
7	29.481	29.449	29.468	29.466	26	27	13	28	29	14	23.7	30	10	.117	.124	.067	.103
8	29.756	29.750	29.773	29.760	14	19	18	15	21	20	18.7	49	-1	.071	.080	.076	.076
9	30.030	29.921	29.736	29.896	9	15	13	10	17	15	14.0	21	-3	.054	.063	.056	.058
10	29.557	29.647	29.595	29.600	25	25	18	26	26	19	23.7	30	3	.123	.123	.087	.111
11	29.670	29.717	29.748	29.712	20	21	17	21	22	18	20.3	25	5	.096	.101	.083	.093
12	29.884	29.779	29.849	29.837	7	9	9	8	10	10	09.3	10	-6	.048	.054	.054	.052
13	29.977	30.035	29.936	29.983	10	11	15	11	12	16	13.0	18	-3	.057	.061	.074	.064
14	29.950	29.881	29.779	29.870	2	12	9	2	13	10	07.0	17	-16	.039	.063	.054	.052
15	29.964	29.719	29.679	29.787	15	23	24	16	25	25	22.0	26	-3	.074	.100	.117	.097
16	29.622	29.581	29.547	29.583	23	26	24	24	28	26	26.0	29	4	.112	.117	.106	.112
17	29.347	29.266	29.454	29.356	24	28	26	26	30	27	27.7	30	12	.106	.130	.129	.122
18	29.763	29.870	29.931	29.855	19	20	16	20	21	17	19.3	27	5	.092	.096	.078	.089
19	30.236	30.288	30.203	30.242	14	20	8	20	22	9	17.0	22	-9	.014	.085	.051	.050
20	29.819	29.643	29.901	29.788	24	32	30	25	35	32	30.7	36	-2	.117	.142	.144	.134
21	30.156	30.027	29.821	30.000	29	34	30	30	37	32	33.0	38	19	.149	.157	.144	.150
22	29.167	29.125	29.116	29.136	38	41	32	41	46	34	40.3	47	15	.190	.192	.155	.179
23	29.544	29.831	29.991	29.789	26	26	24	27	28	25	26.7	30	14	.129	.117	.117	.121
24	29.774	29.552	29.742	29.689	26	36	37	27	39	39	35.5	40	12	.129	.173	.194	.165
25	29.755	29.500	29.156	29.470	32	32	30	34	40	33	42.3	53	23	.153	.303	.321	.259
26	29.347	29.711	29.768	29.609	39	44	35	41	47	37	41.7	51	25	.212	.249	.178	.213
27	29.334	29.059	29.298	29.230	44	50	48	46	56	52	51.3	57	32	.262	.282	.282	.209
28	29.738	29.783	29.693	29.738	32	29	30	33	31	31	31.7	52	16	.168	.137	.153	.153
29	29.874	29.943	29.965	29.928	24	24	21	26	26	23	25.0	35	12	.106	.106	.096	.101
30	30.158	30.248	30.242	30.213	20	17	12	22	18	13	17.7	24	3	.085	.083	.063	.077
31	30.241	30.086	29.879	30.069	5	28	23	6	30	25	20.3	31	-5	.043	.130	.100	.091
Means....	29.749	29.701	29.686	29.710	22.0	26.8	24.6	23.7	27.7	27.7	26.4	57	-16	.109	.127	.123	.117

the northern and northwestern lakes at Charlotte, New York.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.723	.880	.805	.803	S.....	N.....	NE...	2	25	45	21.0	N. 30 E.	10	10	10	.....	.24
.752	.564	.658	.658	NE....	E.....	NE...	4	12	25	12.7	N. 58 E	3	3	4	.....	.08
.727	.554	.658	.646	S.....	NW..	W....	12	4	25	9.7	S. 72 W.	4	6	10	.....	.....
.703	.634	.776	.704	W.....	N.NE..	S.....	2	4	2	0.7	N. 15 E	3	0	0	.....	.45
.692	.636	.854	.727	E.....	E.....	SW...	2	4	2	1.7	S. 74 E	10	8	0	.....	.....
.677	.569	.625	.624	S.....	W.SW	W....	25	25	25	8.3	S. 68 W.	4	10	8	.....	.....
.653	.539	.535	.576	NE...	NE...	NE...	12	25	35	27.3	N. 45 E	3	2	3	.....	.....
.612	.668	.843	.708	E.....	NE...	S	4	4	4	2.3	S. 80 E.	3	9	2	.....	.....
.783	.550	.764	.699	S.....	S.....	N.....	25	4	4	8.3	South..	4	10	10	.....	.....
.812	.651	1.000	.822	W	N.NW.	NW..	4	25	2	10.3	N. 21 W.	10	8	3	.....	.26
.691	.569	.692	.651	W	SW...	S.....	2	4	2	2.3	S. 45 W.	2	1	0	.....	.....
.620	.448	.790	.619	S.....	SW...	W	35	35	2	21.7	S. 24 W.	10	10	10	.....	.....
.685	.681	.698	.688	S.....	N.....	N.....	4	25	2	7.7	North .	10	10	10	.....	.....
.660	.665	.859	.728	N. NE.	NE...	S.....	35	12	2	14.7	N. 29 E	3	3	0	.....	.13
.563	.558	.670	.597	E. SE	S.....	S.....	12	12	35	17.7	S. 12 E	10	3	1	.....	.....
.690	.701	.810	.734	S.....	S.....	S.....	12	4	2	6.0	South..	3	10	1	.....	.....
.761	.634	.862	.752	S.....	S.....	S.....	4	12	2	6.0	South..	6	2	1	.....	.....
.858	605	.738	.737	S.....	S.....	S.....	4	45	2	17.0	South..	10	4	10	.....	23
.786	.644	.838	.736	NE...	NE...	E.....	25	4	2	10.0	N. 48 E	3	0	0	.....	.29
.727	.636	.776	.713	S.....	W	NW..	25	45	12	18.7	S. 73 W.	0	10	3	.....	.....
.687	.740	.692	.706	W	N.....	S.....	2	35	2	11.3	N. 4 W.	6	3	0	.....	.06
.743	.....	.747	.745	W.SW	.....	N.....	12	....	25	7.7	N. 29 W.	8	3	10	.....	.....
.722	.653	.691	.689	NE...	NE...	S.....	25	12	2	12.0	N. 47 E	5	0	0	.....	.....
.572	.493	.631	.565	S.....	S.....	S.....	12	12	4	9.3	South..	0	0	0	.....	.....
.675	.595	.....	.635	W	W	.....	12	....	25	12.3	West ..	10	5	....	.....	.....
.722	.929	.698	.783	E. NE	W	NW..	12	4	4	4.7	N. 9 W.	10	10	0	.....	.13
.732	.631	.867	.743	SW...	N.....	NE...	12	12	2	3.0	N. 57 W.	10	10	0	.....	.....
.777	.559	.884	.740	S.....	S.....	S.....	4	4	12	6.7	South..	0	0	10	.....	.....
.601	.876	.572	.683	S.....	N.....	N	2	45	45	29.3	North..	10	10	10	.....	.....
.577	6.8	.821	.698	N.....	W	S.....	45	12	2	15.0	N. 16 W.	10	5	0	.....	.16
.699	.640	.753	.697	.....	.....	.....	....	....	....	1.8	N. 1 W	6.0	5.5	4.0	.....	2.03
.628	.595	.733	.652	SW...	W	SW...	2	2	2	1.7	S. 56 W.	10	10	0	.....	.....
.512	.588	.671	.590	S. SW.	NW..	NW..	25	4	25	10.3	S. 85 W.	8	8	3	.....	.....
.660	.727	.661	.683	N	NW..	S	12	4	12	1.3	N. 45 W.	10	10	3	.....	.10
.698	.519	.798	.672	SW...	E. SE	S	2	25	35	17.0	S. 25 E	3	6	3	.....	.....
.738	.708	.716	.719	S.....	N.....	SW...	4	4	25	8.3	S. 45 W.	10	10	10	.....	.53
.554	.376	.525	.485	N.....	N.....	N.....	45	35	45	41.7	North..	4	3	5	.....	.06
.617	.376	.....	.497	NE...	NE...	.....	45	4	....	16.3	N. 45 E	5	....	....	.....	.....
.619	.479	.722	.607	S.....	S	S	12	2	2	5.3	South..	2	2	3	.....	.....
.762	.718	.752	.744	S.....	SE...	SW...	4	12	12	7.0	South..	8	10	4	.....	.....
.681	.708	.802	.730	S.....	S.....	S.....	35	4	4	14.3	South..	10	10	10	.....	.03
.790	.703	.867	.787	SW...	SW...	SE...	4	4	2	3.0	S. 28 W.	10	8	10	.....	.27
.790	.925	.767	.827	N.....	N.....	N.....	2	35	35	24.0	North..	10	10	10	.....	.27
.916	.805	.727	.816	W	W	W	4	12	12	9.3	West ..	10	10	7	.....	.49
.829	.653	.859	.780	N.....	N.....	N.....	4	25	4	11.0	North..	2	3	0	.....	.....
.733	.599	.856	.729	W	W	W	4	25	2	10.3	West ..	10	2	2	.....	.....
.738	.663	.761	.701	S.....	S.....	S.....	4	2	12	6.0	South..	0	0	0	.....	.....
.698	.548	.700	.649	S.....	S.....	S.....	25	25	2	17.3	South..	4	3	0	.....	.....
.831	.512	.680	.674	W	SW...	S.....	2	12	4	5.3	S. 40 W.	10	10	0	.....	.....
.692	.599	.780	.690	SW...	SW...	E.....	4	2	2	1.7	S. 26 W.	10	8	2	.....	.....
.874	.677	.841	.797	W	NW..	E.....	2	2	2	0.7	N. 45 W.	1	0	0	.....	.....
.776	.542	.680	.666	S.....	S.....	S.....	12	4	25	13.7	South..	4	6	1	.....	.....
.812	.667	.631	.703	N.....	N.....	N.....	35	25	25	28.3	North..	10	10	3	.....	.02
.587	.461	.619	.556	N.....	N.....	SW...	4	4	2	2.3	N. 12 W.	7	2	0	.....	.....
.893	.577	.738	.736	SW...	NE...	S.....	2	2	4	1.3	South..	3	3	0	.....	.....
.800	.553	.738	.697	SW...	E.....	S.....	2	2	2	1.3	S. 10 E	0	0	0	.....	.....
.694	.521	.738	.651	S.....	NE...	NW..	2	12	2	3.7	N. 44 E	10	0	10	.....	.....
.....	.....	.722	.722	S.....	.....	S.....	2	....	2	1.3	South..	10	....	10	.....	.....
.732	.647	.381	.587	E.....	SE...	S.....	2	2	2	1.6	S. 45 E	10	10	10	.....	.....
.727	.747	.738	.737	E.....	E.....	E.....	25	35	45	35.0	East....	10	10	5	.....	.....
.786	.687	.794	.756	NE...	NE...	SW...	25	4	2	9.0	N. 45 E	10	3	10	.....	.....
.781	.716	.624	.707	N.....	N.....	N.....	2	35	35	24.0	North..	6	6	10	.....	.....
.732	.621	.754	.689	.....	.....	.....	....	....	....	1.9	N. 19 E	7.0	6.0	4.4	.....	1.77

Reductions of the monthly meteorological register of the surgeon of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.							Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Jan. 1	29.869	29.907	29.939	29.905	24	25	20	28	29	23	26.7	29	18	.083	.089	.074	.082
2	29.982	29.947	29.952	29.960	20	21	17	22	24	20	22.0	25	16	.065	.079	.060	.075
3	29.850	29.855	29.897	29.834	17	20	17	19	23	20	20.7	25	13	.071	.074	.060	.068
4	29.783	29.804	29.791	29.793	20	25	26	22	29	30	27.0	30	11	.085	.089	.095	.090
5	29.654	29.358	29.278	29.427	24	32	31	29	37	33	33.0	37	24	.072	.116	.151	.113
6	29.276	29.373	29.421	29.357	23	25	22	25	28	26	26.0	32	21	.100	.100	.072	.091
7	29.527	29.567	29.560	29.551	17	14	7	19	16	10	15.0	25	5	.071	.059	.026	.052
8	29.506	29.393	29.393	29.431	1	11	4	3	14	7	08.0	16	- 4	.023	.037	.018	.029
9	29.454	29.358	29.257	29.356	0	13	14	3	17	18	12.7	18	- 5	.010	.033	.037	.027
10	29.233	29.195	29.260	29.229	9	13	12	12	17	15	14.7	17	6	.031	.033	.041	.035
11	29.353	29.530	29.628	29.504	10	16	14	14	20	17	17.0	21	7	.023	.044	.048	.038
12	29.881	30.008	30.009	29.966	1	10	- 5	2	13	- 2	04.3	20	- 8	.034	.034	....	.034
13	29.829	29.606	29.529	29.655	2	6	7	4	9	10	07.7	10	-12	.025	.023	.026	.025
14	29.669	29.748	29.722	29.713	3	6	- 8	5	9	- 5	03.0	9	-11	.027	.023	....	.025
15	29.735	29.832	29.915	29.827	-13	- 2	-15	-10	- 1	-11	-07.3	4	-19	....	.028	....	.028
16	29.920	29.744	29.554	29.739	-20	13	11	-16	17	14	05.0	18	-27	....	.033	.037	.035
17	29.449	29.474	29.694	29.539	6	9	10	8	11	13	10.7	14	1	.034	.043	.034	.037
18	29.874	29.799	29.744	29.806	- 4	1	1	- 2	3	2	01.0	10	-10	.014	.023	.034	.024
19	29.620	29.499	29.499	29.539	- 2	2	5	- 0	5	9	04.7	9	- 8	.017	.014	.010	.014
20	29.612	29.598	29.546	29.585	- 3	14	7	- 1	18	10	09.0	18	-11	.015	.037	.026	.026
21	29.329	29.248	29.280	29.286	7	12	10	9	14	13	12.0	14	3	.037	.052	.034	.041
22	29.491	29.475	29.580	29.515	11	22	19	14	26	22	20.7	26	8	.037	.072	.069	.059
23	29.670	29.717	29.797	29.728	16	23	25	20	27	29	25.3	29	14	.044	.078	.089	.070
24	29.967	29.996	30.001	29.988	25	26	23	28	30	28	28.7	30	23	.100	.095	.066	.087
25	29.957	29.763	29.361	29.697	22	25	25	25	29	30	28.0	30	20	.084	.089	.078	.084
26	29.136	29.038	39.016	29.063	30	31	26	32	33	29	31.3	33	25	.114	.151	.106	.134
27	29.239	29.341	29.515	29.365	17	18	12	21	21	16	19.3	28	10	.049	.065	.029	.048
28	29.718	29.705	29.637	29.683	9	16	19	11	19	21	17.0	21	5	.043	.056	.080	.060
29	29.540	29.645	29.843	29.676	16	10	5	18	13	8	13.0	20	2	.067	.034	.021	.041
30	30.145	30.160	30.015	30.107	-23	- 2	- 8	-20	- 0	- 5	-08.3	4	-32	....	.017	....	.017
31	29.813	29.752	29.511	29.692	15	24	31	19	28	34	27.0	34	-12	.052	.083	.139	.091
Means....	29.647	29.627	29.617	29.630	09.0	15.3	12.4	11.7	18.6	15.6	15.3	37	-32	.053	.058	.058	.055
Feb. 1	29.282	29.450	29.653	29.428	38	34	28	42	38	31	37.0	43	26	.117	.144	.119	.127
2	29.671	29.499	29.156	29.442	14	24.5	25	18	29	28	25.0	30	10	.037	.080	.100	.072
3	28.941	29.013	29.196	29.050	34	34	32	36	37	35	36.0	38	30	.170	.157	.142	.156
4	29.476	29.540	29.408	29.408	22	33	31	24	37	33	31.3	37	21	.095	.136	.151	.127
5	29.306	29.381	29.576	29.421	25	22.5	26	27	26	29	27.3	32	17	.112	.080	.106	.099
6	29.761	29.783	29.948	29.831	23.5	35	29	27	38	31	32.0	38	23	.086	.165	.137	.129
7	30.069	30.060	30.022	30.050	22	36	33	25	40	36	33.7	41	20	.084	.160	.149	.131
8	29.925	29.799	29.539	29.754	34	42	43	37	50	45	44.0	50	33	.157	.162	.251	.190
9	29.334	29.234	29.113	29.294	41	39	29	44	42	31	39.0	45	28	.218	.199	.137	.185
10	29.584	29.962	30.314	29.953	8	- 2	8	11	0	11	07.3	29	- 4	.028	.017	.028	.024
11	30.500	30.185	30.163	30.283	12	20	27	15	24	30	23.0	30	0	.041	.062	.113	.072
12	30.203	30.147	30.100	30.150	31.5	35	34	34	40	30	37.0	40	25	.145	.139	.144	.143
13	29.989	29.848	29.634	29.824	42	44	44	46	50	48	48.0	50	35	.215	.209	.236	.220
14	29.851	29.986	30.058	29.965	37	32	24	40	35	27	34.0	46	23	.181	.142	.095	.139
15	30.225	30.204	30.099	30.176	14	23	19	16	26	23	21.7	27	10	.059	.089	.056	.068
16	29.695	29.425	29.412	29.511	36	37.5	36	40	41	40	40.3	42	17	.160	.179	.160	.166
17	29.560	29.675	29.805	29.680	34	34	31	37	38	33	36.0	40	30	.127	.144	.151	.151
18	29.836	29.728	29.573	29.712	23	30	25	25	32	28	28.3	32	20	.100	.144	.100	.115
19	29.957	30.014	29.976	29.982	15.5	15	12	18	18	15	17.0	26	18	.059	.052	.041	.051
20	29.863	29.815	29.895	29.858	13	19	12	15	22	16	17.7	22	7	.056	.069	.029	.051
21	29.813	29.631	29.549	29.664	17	27	24	21	31	26	26.0	31	10	.019	.101	.106	.085
22	29.749	29.878	29.951	29.838	20	25	8	23	28	10	20.3	29	7	.074	.100	.040	.071
23	29.885	29.639	29.291	29.605	8	30	32	11	32	35	26.0	35	- 6	.028	.144	.142	.105
24	29.285	29.529	29.758	29.527	36	32	23	38	35	27	33.3	38	24	.186	.142	.078	.135
25	29.935	29.926	29.845	29.902	13	20.5	16	15	24	19	19.3	26	9	.056	.070	.056	.061
26	29.888	29.924	25.971	29.928	10	24	21	12	28	28	22.7	32	8	.046	.083	.083	.071
27	30.146	30.173	30.154	30.158	22	24.5	20	26	29	23	26.0	30	18	.072	.080	.074	.075
28	29.979	29.763	29.743	29.828	19	35	34	22	43	32	34.3	44	11	.069	.100	.144	.104
Means....	29.776	29.755	29.746	29.759	23.7	28.8	26.0	26.6	22.6	29.1	29.4	59	- 6	.102	.120	.113	.112

the northern and northwestern lakes at Charlotte, New York.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
.653	.479	.620	.584	SW...	S.....	S.....	4	12	4	6.3	S. 8 W	8	7	0	.....	.....
.698	.521	.631	.617	SW...	NW...	NW ..	45	60	25	32.0	N. 73 W	10	6	0	.....	.....
.607	.502	.692	.600	E....	E. SE.	S.....	25	25	60	28.3	S. 35 E	10	10	10	.....	.....
.522	.494	.712	.576	N.....	N.....	N.....	45	12	4	20.3	North ..	10	6	2	.....	.....
.694	.515	.567	.592	S.....	S.....	S.....	4	25	35	21.3	South ..	1	10	10	.....	.....
.537	.619	.694	.617	N.....	N.....	S.....	35	12	4	14.3	North ..	7	7	9	.....	.01
.788	.661	.800	.750	E.....	E.....	SE....	12	25	4	13.3	S. 86 E	10	10	0	.....	.....
.645	.....	.592	.619	SE....	.....	S.....	4	....	4	2.3	S. 24 E	10	....	10	.....	.....
.561	.575	.716	.617	S.....	N.....	S.....	12	35	12	3.7	North ..	10	10	0	.....	.....
.762	.584	.722	.689	S.....	S.....	S.....	12	4	12	9.3	South ..	5	10	6	.....	.....
.811	.645	.698	.718	SW ...	W	NW...	4	12	4	5.9	West...	10	10	4	.....	.....
.712	.619	.797	.709	NW...	NW...	NW..	12	25	35	24.0	N. 45 W	8	10	10	.....	.02
.782	.628	1.000	.803	N.....	N.....	NE ..	12	35	4	16.7	N. 3 E..	10	8	10	.....	.01
.617	.597	.527	.580	S.....	W	N	12	25	12	8.3	West...	10	10	8	.....	.....
.569	.527	.694	.597	N.....	W	S.....	12	4	4	3.0	N. 27 W	10	8	10	.....	.....
.653	.802	.794	.750	W	W	W	35	25	35	31.7	West...	4	10	10	.....	.....
.685	.653	.894	.744	W	W	N.....	2	25	45	17.7	N. 31 W.	10	7	10	.....	.10
.702	.515	.712	.643	N.....	N.....	S.....	12	2	2	4.0	North ..	10	10	10	.....	.....
.702	.569	.768	.680	N.....	N.....	S.....	45	2	12	10.7	North ..	10	10	10	.....	.....
.628	.661	.744	.678	S.....	SW...	N.....	12	12	25	2.7	S. 86 W.	10	10	2	.....	.....
.705	.738	.792	.745	E.....	E.....	E.....	12	12	4	9.3	East ...	10	10	2	.....	.....
.820	.653	.772	.748	S.....	SE....	S.....	4	4	12	6.3	S. 8 E..	10	10	10	.....	.....
.767	.....	.781	.774	S.....	.....	S.....	12	.....	2	4.7	South ..	10	.....	0	.....	.01
.829	.151	.809	.596	S.....	S.....	S.....	12	2	4	6.0	South ..	10	10	10	.....	.....
.794	.....	.692	.743	S.....	.....	S.....	12	.....	12	8.0	South ..	10	....	10	.....	.03
.762	.738	.628	.709	W	W	W	35	25	12	24.0	West...	10	10	10	.....	.04
.628	.577	.645	.617	NW...	S.....	S.....	2	4	2	1.7	S. 16 W.	10	10	10	.....	.....
.732	.694	.738	.718	E.....	E.....	S.....	2	2	2	1.7	S. 67 E	10	10	10	.....	.04
.829	.840	.669	.779	E.....	E.....	W	12	12	25	0.3	West...	10	10	10	.....	.....
.702	.671	.648	.674	W	W	W	45	25	25	31.7	West...	10	10	10	.....	.33
.697	.601	.718	.725	.....	.....	.....	....	....	....	4.1	N 79 W.	9.1	9.2	7.1	.....	.65
.692	.644	.665	.667	S.....	S.....	S.....	25	2	25	17.3	South .	10	10	10	....!	.....
.644	.619	.610	.624	S.....	SW...	SW ..	2	12	4	6.0	S. 41 W.	10	10	10	.....	.13
.703	.712	.8 0	.738	W	W	W	12	35	35	27.3	West ..	10	10	10	.....	.....
.810	.738	.850	.799	W	S.....	S.....	4	2	2	2.0	S. 45 W	10	10	9	.....	.....
.746	.....	.782	.764	S.....	.....	W	2	....	2	1.0	S. 45 W	10	....	10	.....	.....
.712	.719	.646	.692	S.....	S.....	S.....	12	35	60	35.7	South ..	10	10	10	.....	.02
.768	.775	.816	.786	W	W	W	2	2	35	13.0	West...	9	10	10	.....	.....
.823	.712	.702	.746	W	SW...	SW ...	35	35	12	25.3	S. 64 W.	10	10	10	.....	.15
.791	.671	.648	.703	N.....	NW...	S.....	12	4	12	1.5	N. 45 W.	10	10	10	.....	.57
.876	.876	.845	.866	N.....	N.....	S.....	12	12	4	6.7	North ..	3	8	10	.....	.09
.855	.860	.840	.852	S.....	N.....	N.....	2	12	25	11.7	North ..	5	10	10	.....	.....
.777	.791	.791	.786	NE ...	NE ...	NE ...	65	65	65	65.3	N. 45 E	10	10	10	.....	.04
.797	.804	.829	.810	NE ...	NE ...	NE ...	45	25	35	35.0	N. 45 E	10	10	10	.....	.25
1.000	.810	.791	.867	E.....	E.....	E.....	2	2	2	2 0	East ...	3	10	1	.....	.01
.829	.746	.872	.816	E.....	E.....	E.....	2	12	2	5.3	East ...	10	10	10	.....	.05
.868	.768	.754	.797	W	W	S.....	4	12	2	5.7	S. 83 W.	10	10	10	.....	.04
.754	.782	.880	.805	SE....	E.....	N.....	12	2	4	3.7	S. 66 E.	10	10	10	.....	.01
.850	.855	.834	.849	N.....	N.....	N.....	12	12	12	12.0	North ..	10	10	10	.....	.....
.128	.721	.784	.544	NW ..	NW...	E.....	2	2	4	1.0	N. 23 E	10	10	10	.....	.....
.872	.698	.794	.788	S.....	S.....	W	35	25	4	20.3	S. 4 W.	10	10	10	.....	.....
.890	.712	.794	.899	W	E	E.....	2	2	45	15.0	East ...	10	10	10	.....	.02
.738	.617	.792	.716	SE....	SW ...	W	25	35	45	22.3	S. 51 W.	10	5	10	.....	.....
.880	.708	.872	.840	W	W	W	45	25	25	31.7	West...	10	10	4	.....	.01
.880	.726	.816	.807	SE....	S.....	W	2	2	12	3.7	S. 73 W.	10	10	10	.....	.....
.792	.820	.798	.803	W	E.....	S.....	4	2	35	12.0	S. 4 W.	10	10	10	.....	.....
.824	.772	.807	.801	SW ...	W	SW ..	12	35	12	18.3	S. 72 W.	5	3	3	.....	.....
.843	.627	.727	.732	S.....	S.....	W	25	12	25	15.0	S. 34 W.	10	10	10	.....	.15
.893	.788	.893	.858	NW..	N.....	S.....	12	12	2	6.7	N. 25 W.	3	10	10	.....	.14
.754	.754	.730	.746	NW...	NW...	NW...	35	35	35	35.0	N. 45 W.	8	8	10	.....	.01
.721	.840	.810	.790	NW..	NW...	NW...	25	25	2	17.3	N. 45 W.	10	10	2	.....	.02
.760	.782	.746	.763	S.....	S.....	E.....	2	2	12	4.3	S. 72 E	3	9	10	.....	.04
.786	.750	.794	.805	.....	.....	.....	....	....	....	3.1	N. 85 W.	8.7	9.4	8.7	.....	1.73

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.								
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	Elasticity, in U. S. inches and decimals. 7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
Jan. 1	29.869	29.907	29.939	29.905	24	25	20	28	29	23	26.7	29	18	.083	.089	.074	.082
2	29.982	29.947	29.952	29.960	20	21	17	22	24	20	22.0	25	16	.085	.078	.060	.075
3	29.850	29.855	29.897	29.834	17	21	17	19	23	20	20.7	25	13	.071	.074	.060	.068
4	29.783	29.804	29.791	29.793	20	25	26	22	29	30	27.0	30	11	.085	.089	.095	.090
5	29.654	29.358	29.278	29.427	24	32	31	29	37	33	33.0	37	24	.072	.116	.151	.113
6	29.276	29.373	29.421	29.357	23	25	22	25	28	26	26.0	32	21	.100	.100	.072	.091
7	29.527	29.567	29.560	29.551	17	14	7	19	16	10	15.0	25	5	.071	.059	.026	.052
8	29.506	29.393	29.393	29.431	1	11	4	3	14	7	08.0	16	- 4	.023	.037	.018	.059
9	29.454	29.358	29.257	29.356	0	13	14	3	17	18	12.7	18	- 5	.010	.033	.037	.027
10	29.233	29.195	29.260	29.229	9	13	12	12	17	15	14.7	17	6	.031	.033	.041	.035
11	29.353	29.530	29.628	29.504	10	16	14	14	20	17	17.0	21	7	.023	.044	.048	.038
12	29.881	30.008	30.009	29.966	1	10	- 5	2	13	- 2	04.3	20	- 8	.034	.034	....	.034
13	29.929	29.606	29.529	29.655	2	6	7	4	9	10	07.7	10	-12	.025	.023	.026	.025
14	29.669	29.748	29.722	29.713	3	6	- 8	5	9	- 5	03.0	9	-11	.027	.023	....	.025
15	29.735	29.832	29.915	29.827	-13	- 2	-15	-10	- 1	-11	-07.3	4	-19	....	.028	....	.028
16	29.920	29.744	29.554	29.739	-20	13	11	-16	17	14	05.0	18	-27	....	.033	.037	.035
17	29.449	29.474	29.694	29.539	6	9	10	8	11	13	10.7	14	1	.034	.043	.034	.037
18	29.874	29.799	29.744	29.806	- 4	1	1	- 2	3	2	01.0	10	-10	.014	.023	.034	.024
19	29.620	29.499	29.499	29.539	- 2	2	5	- 0	5	9	04.7	9	- 8	.017	.014	.010	.014
20	29.612	29.598	29.546	29.585	- 3	14	7	- 1	18	10	09.0	18	-11	.015	.037	.026	.026
21	29.329	29.248	29.280	29.286	7	12	10	9	14	13	12.0	14	3	.037	.052	.034	.041
22	29.491	29.475	29.580	29.515	11	22	19	14	26	22	20.7	26	8	.037	.072	.069	.059
23	29.670	29.717	29.797	29.728	16	23	25	20	27	29	25.3	29	14	.044	.078	.089	.070
24	29.967	29.996	30.001	29.988	25	26	29	28	30	28	28.7	30	23	.100	.095	.066	.087
25	29.957	29.763	29.361	29.697	22	25	25	25	29	30	28.0	30	20	.084	.089	.078	.084
26	29.136	29.038	29.016	29.063	30	31	26	32	33	29	31.3	33	25	.144	.151	.106	.134
27	29.239	29.341	29.515	29.365	17	18	12	21	21	16	19.3	28	10	.049	.065	.029	.048
28	29.718	29.705	29.637	29.683	9	16	19	11	19	21	17.0	21	5	.043	.056	.080	.060
29	29.540	29.645	29.843	29.676	16	10	5	18	13	8	13.0	20	2	.067	.034	.021	.041
30	30.145	30.160	30.015	30.107	-23	- 2	- 8	-20	- 0	- 5	-08.3	4	-32	....	.017	....	.017
31	29.813	29.752	29.511	29.692	15	24	31	19	28	34	27.0	34	-12	.052	.083	.139	.091
Means....	29.647	29.627	29.617	29.630	09.0	15.3	12.4	11.7	18.6	15.6	15.3	37	-32	.053	.058	.058	.055
Feb. 1	29.282	29.450	29.653	29.428	38	34	28	42	38	31	37.0	43	26	.117	.144	.119	.127
2	29.671	29.499	29.156	29.442	14	24.5	25	18	29	28	25.0	30	10	.037	.089	.100	.072
3	28.941	29.013	29.196	29.050	34	34	32	36	37	35	36.0	38	30	.170	.157	.142	.156
4	29.476	29.540	29.408	29.408	22	33	31	24	37	33	31.3	37	21	.095	.136	.151	.127
5	29.306	29.381	29.576	29.421	25	22.5	26	27	26	29	27.3	32	17	.112	.080	.106	.099
6	29.761	29.783	29.948	29.831	23.5	35	29	27	38	31	32.0	38	23	.086	.165	.137	.129
7	30.069	30.060	30.022	30.050	22	36	33	25	40	36	33.7	41	20	.084	.160	.149	.131
8	29.925	29.799	29.529	29.754	34	42	43	37	50	45	44.0	50	33	.157	.162	.251	.190
9	29.334	29.234	29.113	29.294	41	39	29	44	42	31	39.0	45	28	.218	.199	.137	.185
10	29.584	29.962	30.314	29.953	8	- 2	8	11	0	11	07.3	29	- 4	.028	.017	.028	.024
11	30.500	30.185	30.163	30.283	12	20	27	15	24	30	23.0	30	0	.041	.062	.113	.072
12	30.203	30.147	30.100	30.150	31.5	35	34	34	40	30	37.0	40	25	.145	.139	.144	.143
13	29.989	29.848	29.634	29.824	42	44	44	46	50	48	48.0	50	35	.215	.209	.236	.220
14	29.851	29.986	30.058	29.965	37	32	24	40	35	27	34.0	46	23	.181	.142	.095	.139
15	30.225	30.204	30.099	30.176	14	23	19	16	26	23	21.7	27	10	.059	.089	.058	.069
16	29.695	29.425	29.419	29.511	36	37.5	36	40	41	40	40.3	42	17	.160	.179	.160	.166
17	29.560	29.675	29.805	29.680	34	34	31	37	38	33	36.0	40	30	.157	.144	.151	.151
18	29.836	29.728	29.573	29.712	23	30	25	25	32	28	28.3	32	20	.100	.144	.100	.115
19	29.957	30.014	29.976	29.982	15.5	15	12	18	18	15	17.0	26	18	.059	.052	.041	.051
20	29.863	29.815	29.895	29.858	13	19	12	15	22	16	17.7	22	7	.056	.069	.029	.051
21	29.813	29.631	29.549	29.664	17	27	24	21	31	26	26.0	31	10	.049	.101	.106	.085
22	29.749	29.878	29.951	29.838	20	25	8	23	28	10	20.3	29	7	.074	.100	.049	.071
23	29.885	29.639	29.291	29.605	8	30	32	11	32	35	26.0	35	- 6	.028	.144	.142	.105
24	29.285	29.520	29.758	29.527	36	32	23	38	35	27	33.3	38	24	.186	.142	.078	.135
25	29.935	29.926	29.845	29.902	13	20.5	16	15	24	19	19.3	26	9	.056	.070	.056	.061
26	29.888	29.924	25.971	29.928	10	24	21	12	28	28	22.7	32	8	.046	.083	.083	.071
27	30.146	30.173	30.154	30.158	22	24.5	20	26	29	23	26.0	30	18	.072	.080	.074	.075
28	29.979	29.763	29.743	29.828	19	35	34	22	43	32	34.3	44	11	.069	.100	.144	.104
Means....	29.776	29.755	29.746	29.759	23.7	28.8	26.0	26.6	22.6	29.1	29.4	59	- 6	.102	.120	.113	.112

the northern and northwestern lakes at Sackett's Harbor, New York.

VAPOR.				WIND.								Amount of cloudiness, (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											o					
.543	.556	.598	.566	SW..	NW..	Calm..	4	4	0	1.0	S. 67 W.	10	10	10	.....	.....
.721	.610	.556	.629	Calm..	S	S	0	2	12	4.7	South..	10	9	10	.....	.....
.692	.598	.556	.615	S	S	Calm..	4	12	0	5.3	South..	10	7	0	.....	.....
.721	.556	.569	.615	S	S	S	4	4	2	3.3	South..	8	9	8	.....	.....
.449	.527	.800	.592	SE....	S	S	4	4	12	6.3	S. 8 E..	10	6	10	.....	.....
.746	.655	.515	.639	NW..	NW..	NW..	12	4	2	6.0	N.45 W.	10	10	10	.....	.02
.692	.659	.377	.576	N	NW..	NW..	4	4	2	3.0	N.27 W.	10	2	0	.....	.....
.460	.457	.308	.408	Calm..	Calm..	Calm..	0	0	0	0.0	Calm ..	0	9	0	.....	.....
.193	.350	.371	.305	Calm..	SW..	Calm..	0	2	0	0.7	S. 45 W.	0	9	10	.....	.....
.418	.359	.475	.414	NE ...	NE ...	NE ...	12	4	2	6.0	N. 45 E	9	8	10	.....	.....
.280	.412	.509	.400	NE ...	NW..	Calm..	2	2	0	0.9	North..	10	5	2	.....	.....
.718	.438	.....	.578	NE ...	NW..	N	2	2	2	1.6	North..	4	2	3	.....	.....
.480	.356	.377	.404	NE ...	NE ...	NE ...	12	12	25	15.3	N. 45 E	10	10	10	.....	.....
.500	.356	.....	.428	NE ...	N	Calm..	2	4	0	2.0	N. 13 E.	3	5	3	.....	.02
.....	.683	.....	.683	NE ...	NE ...	Calm..	2	2	0	1.3	N. 45 E.	4	3	0	.....	.....
.....	.350	.457	.404	NE ...	S	NE ...	4	2	4	2.3	N. 58 E.	6	8	10	.....	.....
.553	.596	.438	.529	NE ...	NE ...	N	12	25	4	13.3	N. 41 E.	10	10	4	.....	.....
.345	.460	.718	.508	N	NW...	NW ..	2	4	2	2.7	N.32 W.	3	4	2	.....	.02
.393	.253	.146	.264	W	W	W	2	4	4	3.3	West ..	4	6	4	.....	.....
.369	.371	.377	.372	E	NE ...	NE ..	2	2	12	5.0	N. 49 E	9	6	8	.....	.....
.568	.635	.438	.547	NE ...	NE ...	NE ...	12	25	4	13.7	N. 45 E	10	10	10	.....	.12
.457	.515	.584	.519	Calm..	S	W	0	2	4	1.7	S. 67 W.	9	8	10	.....	.20
.412	.529	.556	.499	W	W	W	4	2	2	2.7	West ..	10	9	10	.....	.....
.655	.569	.433	.552	NW ..	NW ..	NW ..	4	4	2	3.3	N.45 W.	10	10	10	.....	.....
.622	.556	.465	.548	Calm..	SE....	Calm..	0	2	0	0.7	S. 45 E	10	5	10	.....	.....
.794	.800	.665	.753	S	S	SW ..	12	12	35	18.0	S. 27 W.	10	10	10	.....	.08
.431	.570	.327	.443	W	W	W	25	12	12	16.3	West ..	10	10	4	.....	.18
.596	.541	.712	.616	NW...	W	SW...	4	4	35	12.7	S. 55 W.	10	3	10	.....	.....
.682	.438	.334	.485	W	W	NW ..	35	12	4	16.7	N.87 W.	10	3	0	.....	.22
.....	.393	.....	.393	NE ...	Calm..	Calm..	2	0	0	0.7	N. 45 E	0	0	10	.....	.....
.525	.543	.712	.593	S	S	S	4	4	12	6.7	South..	10	9	10	.....	.....
.536	.458	.495	.512	.....	.....	.....	....	....	....	0.9	N.77 W.	7.7	7.0	6.7	.....	.86
.661	.628	.685	.658	SW ...	W	W	12	12	2	8.0	S. 69 W.	5	7	3	.....	.18
.371	.498	.655	.508	NE ...	NE ...	NE ...	2	4	25	10.3	N. 45 E.	3	10	10	.....	.....
.802	.712	.698	.737	SW ..	SW ..	SW ..	12	12	12	12.0	S. 45 W.	10	10	10	.....	1.22
.738	.619	.800	.719	W	S	NE ...	4	4	12	2.0	N. 45 E.	2	5	10	.....	.30
.761	.574	.665	.667	NE ...	NE ...	S	12	2	2	4.0	N. 50 E.	10	10	10	.....	.08
.587	.719	.788	.698	Calm..	SW ..	SW ..	0	2	4	2.0	S. 45 W.	10	3	8	.....	.06
.622	.645	.705	.657	S	S	S	4	4	2	3.3	South..	2	4	0	.....	.....
.712	.450	.840	.667	Calm..	S	Calm..	0	4	0	1.3	South..	1	4	10	.....	.....
.756	.744	.788	.763	S	SW ..	N	12	2	12	0.7	S. 45 W.	10	10	10	.....	.26
.398	.393	.398	.396	NW..	NW...	NW...	12	12	12	12.0	N.45 W.	8	5	0	.....	.30
.475	.483	.675	.544	S	S	S	4	25	25	18.0	South..	10	8	3	.....	.....
.756	.557	.628	.647	S	S	Calm..	12	2	0	4.7	South..	10	9	10	.....	.....
.691	.581	.704	.659	S	S	S	4	12	25	13.7	South..	6	9	10	.....	.....
.732	.698	.644	.691	S	NE ...	NE ...	2	4	12	5.0	N. 49 E	10	10	8	.....	.26
.659	.634	.467	.587	NE ...	NE ...	NE ...	12	12	4	9.3	N. 45 E	7	2	5	.....	.....
.645	.695	.645	.662	S	S	S	4	35	25	21.3	South..	10	10	8	.....	.02
.712	.628	.800	.710	SW ..	SW ..	W	12	25	4	13.3	S. 49 W.	9	10	0	.....	.12
.746	.794	.655	.732	NE ...	NE ...	NE ...	2	2	4	2.7	N. 45 E	6	10	10	.....	.....
.602	.525	.475	.534	NE ...	NE ...	NE ...	2	4	4	3.3	N. 45 E.	10	2	8	.....	.02
.648	.584	.327	.520	NE ...	NE....	NE ...	12	4	2	6.0	N. 45 E	10	8	8	.....	.....
.431	.582	.754	.589	NE ...	NE ...	NE....	2	4	2	2.7	N. 45 E	10	10	10	.....	.....
.598	.655	.582	.612	SW ..	W	Calm..	2	12	0	4.7	S. 84 W.	10	6	0	.....	.12
.398	.794	.698	.630	Calm..	S	S	0	12	35	15.7	South..	10	10	10	.....	.....
.811	.698	.529	.679	W	W	NW..	35	25	4	20.7	N. 88 W.	8	7	9	.....	.06
.648	.547	.541	.579	NE ...	NE ...	NE ...	4	2	2	2.7	N. 45 E.	0	2	3	.....	.....
.610	.543	.543	.565	NE ...	SW ..	SW ..	2	2	4	1.3	S. 45 W.	4	10	0	.....	.....
.515	.503	.598	.505	NW...	NE ...	Calm..	2	4	0	1.7	N. 16 E.	10	0	5	.....	.....
.584	.357	.628	.523	Calm..	S	Calm..	0	12	0	4.0	South..	10	10	0	.....	.....
.631	.601	.636	.623	.....	.....	.....	....	....	....	2.4	S. 24 W.	7.5	7.2	6.3	.....	3.09

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
March 1	29.633	29.433	29.117	29.394	23	32	41	27	36	47	36.7	47	21	.078	.129	.179	.129
2	29.085	29.287	29.711	29.361	37	30	13	41	32	16	29.7	45	15	.168	.144	.044	.119
3	29.899	29.869	29.720	29.829	4	16	17	6	18	20	14.7	29	0	.030	.067	.060	.052
4	29.537	29.559	29.782	29.626	19	20	17	21	22	20	21.0	26	15	.089	.085	.060	.078
5	29.968	30.000	30.091	30.020	17	33	19	21	37	23	27.0	37	14	.049	.136	.058	.081
6	30.245	30.228	30.039	30.171	10	28	21	13	32	14	23.0	32	7	.034	.108	.079	.074
7	29.822	29.711	29.981	29.838	21	29	20	23	31	23	25.7	31	18	.090	.137	.074	.100
8	30.207	30.208	30.149	30.188	8	30	17	10	33	20	21.0	35	4	.040	.132	.060	.077
9	30.037	29.980	29.985	30.001	21	33	32	25	38	34	32.3	38	10	.067	.123	.155	.115
10	29.898	29.652	29.407	29.652	25	40	40	28	47	44	39.7	47	23	.100	.156	.195	.150
11	29.647	29.782	29.839	29.756	35	35	32	39	40	35	38.0	43	32	.152	.139	.142	.144
12	29.700	29.547	29.633	29.627	32	34	31	35	38	33	35.3	38	29	.142	.144	.151	.146
13	29.655	29.552	29.538	29.582	30	35	23	32	38	26	32.0	38	23	.144	.165	.089	.133
14	29.834	29.889	29.955	29.893	9	23	14	12	27	17	18.7	27	5	.031	.078	.048	.052
15	30.098	30.116	30.109	30.108	15	23	20	17	26	23	22.0	27	9	.063	.089	.074	.075
16	30.148	29.961	29.781	29.963	13	28	24	17	31	27	25.0	31	10	.033	.119	.095	.082
17	29.409	29.373	29.383	29.388	20	32	22	23	34	25	27.3	34	17	.074	.155	.084	.104
18	29.657	29.715	29.757	29.710	15	22	20	17	25	22	21.3	25	12	.063	.084	.085	.077
19	29.947	29.965	30.076	29.999	10	32	20	14	35	24	24.3	35	8	.023	.142	.082	.076
20	30.192	30.185	30.143	30.173	10	33	23	12	37	26	25.0	37	1	.046	.136	.089	.090
21	30.087	30.082	29.854	29.981	20	36	36	23	42	41	35.3	43	15	.074	.134	.147	.118
22	29.845	29.834	29.944	29.874	29	35	32	31	40	35	35.3	41	27	.137	.139	.142	.139
23	30.018	29.981	29.946	29.982	24	38	35	28	42	39	36.3	43	25	.083	.177	.152	.137
24	29.924	29.813	29.662	29.800	33	40	39	38	47	43	42.7	47	33	.123	.156	.186	.155
25	29.730	29.801	29.917	29.816	36	37	29	39	42	31	37.3	43	28	.173	.155	.137	.155
26	30.048	29.952	29.851	29.950	21	28	26	24	31	29	28.0	33	19	.079	.119	.106	.101
27	29.639	29.631	29.431	29.567	24	29	24	28	31	27	28.7	31	22	.083	.137	.085	.105
28	29.419	29.440	29.438	29.432	23	32	28	26	35	30	30.3	37	21	.089	.142	.130	.120
29	29.473	29.378	29.353	29.401	22	32	32	25	34	35	31.3	36	19	.084	.155	.142	.127
30	29.385	29.315	29.275	29.325	30	33	34	32	38	39	36.3	39	27	.144	.123	.131	.133
31	29.422	29.479	29.432	29.444	32	42	38	36	47	42	41.7	47	31	.129	.202	.177	.169
Means....	29.794	29.762	29.752	29.769	21.5	31.3	26.4	24.6	35.0	29.7	29.8	47	0	.087	.132	.111	.110
April 1	29.160	29.112	29.153	29.142	40	41	35	43	43	38	41.3	46	34	.208	.231	.165	.201
2	29.275	29.417	29.662	29.451	37	36	34	39	40	38	39.0	44	33	.194	.160	.144	.166
3	29.944	29.914	29.842	29.900	32	38	34	34	41	37	37.3	42	28	.155	.190	.157	.167
4	29.692	29.463	29.452	29.536	37	49	36	41	57	38	45.3	57	32	.168	.242	.186	.199
5	29.253	29.193	29.155	29.201	33	35	34	36	38	37	37.0	39	32	.149	.165	.157	.151
6	29.348	29.507	29.485	29.447	28	35	34	31	39	37	35.7	39	27	.119	.152	.157	.143
7	29.470	29.556	29.747	29.591	37	40	36	43	45	40	42.7	46	33	.142	.182	.160	.161
8	29.775	29.602	29.800	29.726	34	41	35	37	45	38	40.0	46	33	.157	.205	.165	.176
9	29.991	29.973	29.832	29.932	34	39	34	37	43	37	39.0	44	32	.157	.186	.157	.167
10	29.702	29.534	29.380	29.539	30	39	37	32	44	39	38.3	45	28	.144	.173	.194	.170
11	29.485	29.577	29.572	29.545	30	33	33	32	37	37	35.3	39	29	.144	.136	.136	.139
12	29.587	29.596	29.529	29.571	32.5	42	38	35	48	49	44.0	49	30	.152	.189	.086	.142
13	29.715	29.787	29.850	29.784	31	35	36	33	41	40	38.0	44	31	.151	.126	.160	.146
14	29.986	29.884	29.783	29.851	31	49	50	33	57	57	49.0	60	30	.151	.242	.286	.226
15	29.635	29.544	29.512	29.564	50	60	54	57	67	58	60.7	68	52	.268	.425	.365	.353
16	29.445	29.362	29.325	29.377	56	53	48	59	56	52	55.7	64	48	.409	.363	.322	.352
17	29.501	29.575	29.638	29.571	42	46	42	46	54	47	49.0	54	41	.215	.206	.229	.216
18	29.870	29.918	29.981	29.923	38	43	40	41	47	43	43.7	48	36	.190	.225	.228	.208
19	30.016	29.839	29.716	29.857	31	49	45	32	54	49	45.0	56	31	.162	.222	.247	.210
20	29.576	29.381	29.255	29.404	48	60	48	54	68	53	58.3	69	45	.256	.411	.269	.312
21	29.418	29.480	29.456	29.451	40	45	40	43	49	44	45.3	53	39	.208	.247	.195	.217
22	29.336	29.231	29.406	29.324	40	39	37	42	42	39	41.0	44	36	.221	.199	.194	.205
23	29.677	29.770	29.891	29.779	31	35.5	32	33	38	35	35.3	40	30	.151	.175	.142	.156
24	29.979	29.885	29.819	29.894	31	43	38	33	46	40	39.7	47	28	.151	.238	.203	.197
25	29.884	29.935	29.821	29.880	35.5	40	39	39	44	44	42.3	48	35	.162	.195	.173	.177
26	29.798	29.724	29.553	29.692	42	53	46	46	60	53	53.0	61	38	.215	.310	.219	.248
27	29.431	29.611	29.744	29.595	44	39	30	48	43	32	41.0	53	30	.236	.186	.144	.189
28	29.964	29.942	29.873	29.926	27	39	35	29	45	38	37.3	46	22	.124	.160	.165	.146
29	29.834	29.778	29.746	29.786	37	44	44	41	51	47	46.3	53	30	.166	.196	.249	.204
30	29.583	29.535	29.452	29.523	48	56	56	52	59	59	56.7	61	44	.222	.340	.409	.357
Means....	29.644	29.621	29.611	29.625	36.6	43.2	39.4	40.0	48.0	43.2	43.7	69	22	.187	.236	.198	.204

the northern and northwestern lakes at Sackett's Harbor, New York.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.529	.610	.554	.564	NE...	NE...	S.....	4	2	12	3.0	S. 28 E	9	8	10	.....	.....
.653	.794	.492	.646	W	W	NE...	4	35	12	10.7	N.74 W.	10	8	3	.....	.22
.520	.682	.556	.586	NE...	NE...	NE...	4	2	4	3.3	N. 45 E	0	9	10	.....	.....
.712	.721	.556	.663	E.....	NE...	Calm..	0	4	0	1.7	N. 61 E	10	10	10	.....	.06
.431	.619	.467	.509	Calm..	S.....	S.....	3	4	2	2.0	South..	9	8	0	.....	.....
.438	.594	.610	.547	Calm..	NE...	NE...	0	4	4	2.7	N. 45 E	8	7	10	.....	.....
.730	.788	.598	.705	E	NE...	Calm..	12	2	0	4.7	N. 85 E.	10	10	1	.....	.08
.582	.703	.556	.614	Calm..	Calm..	Calm..	0	0	0	0 0	Calm...	0	3	4	.....	.06
.500	.537	.792	.610	E.....	S.....	Calm..	2	12	0	4.3	S. 9 E..	10	10	10	.....	.....
.655	.483	.677	.605	E.....	S.....	S.....	2	12	35	16.0	S. 3 E..	9	10	10	.....	.....
.636	.557	.698	.630	W	W	Calm..	4	2	0	2.0	West...	7	5	10	.....	.50
.698	.628	.800	.709	NE ...	NE...	NE...	2	4	2	2.7	N. 45 E	10	10	10	.....	.....
.794	.719	.634	.716	Calm..	SW...	SW...	0	2	25	9.0	S. 45 W.	10	10	10	.....	.26
.418	.529	.509	.485	NW ..	NW ..	NW ..	4	12	12	9.3	N. 45 W.	3	4	5	.....	.....
.761	.634	.598	.664	NW ..	SW...	SW...	2	4	2	2.0	S. 62 W.	8	10	4	.....	.....
.359	.685	.644	.560	Calm..	NE...	NE...	0	2	4	2.0	N. 45 E	6	10	10	.....	.....
.598	.792	.622	.671	NE...	SW...	SW...	12	4	12	1.3	S. 45 E.	10	10	8	.....	.06
.761	.622	.721	.701	W	W	W	12	12	12	12.0	West...	5	6	5	.....	.08
.280	.698	.483	.487	Calm..	SW...	Calm..	0	2	0	0.7	S. 45 W.	0	1	0	.....	.....
.610	.619	.634	.621	SE....	NE...	NE...	2	2	2	1.7	N. 74 E.	0	0	2	.....	.....
.598	.500	.567	.555	NE...	NE...	E.....	4	2	2	2.7	N. 58 E.	9	8	10	.....	.....
.788	.557	.698	.681	NE...	NE...	N.....	4	12	2	6.0	N. 40 E.	8	6	7	.....	.....
.543	.661	.636	.613	NE...	W	Calm..	2	2	0	0.7	N. 17 W.	9	8	10	.....	.....
.537	.483	.669	.563	S.....	S.....	S.....	2	4	12	6.0	South..	10	9	10	.....	.....
.726	.577	.788	.697	SW...	SW...	NW ..	12	12	4	8.0	S. 53 W.	10	4	10	.....	.20
.610	.685	.665	.653	N.....	N.....	N.....	12	4	4	6.7	North..	0	4	2	.....	.....
.543	.788	.644	.658	NE...	NE...	NE...	4	12	2	6.0	N. 45 E.	10	10	10	.....	.....
.631	.698	.782	.705	NW ..	W	N.....	2	4	2	2.3	N. 58 W.	7	5	0	.....	.04
.622	.792	.698	.704	NW ..	W	SW...	12	12	4	8.0	N. 77 W.	0	8	9	.....	.....
.794	.537	.547	.626	SW...	SW...	SW...	4	25	25	18.0	S. 45 W.	8	10	10	.....	.....
.610	.624	.661	.632	SW...	SW...	SW...	2	12	2	5.3	S. 45 W.	0	0	0	.....	.....
.602	.642	.631	.625	.....	.....	.....	....	....	....	1.6	S. 65 W.	6.6	7.1	6.8	.....	1.56
.750	.833	.719	.767	S.....	SW...	SW...	4	25	25	17.3	S. 43 W.	10	10	10	.....	.....
.816	.645	.628	.696	W	W	W	12	25	25	20.7	West...	10	5	8	.....	.32
.792	.738	.712	.747	NW ..	W	NW ..	2	2	2	1.7	S. 61 W.	0	0	8	.....	.....
.653	.521	.811	.662	S.....	S.....	NE...	2	12	12	3.3	S. 57 E	9	10	10	.....	.....
.705	.719	.712	.712	NE...	SW...	SW...	25	12	25	4.0	S. 43 W.	10	10	10	.....	.58
.685	.636	.712	.678	NW ..	W	S.....	12	4	4	4.3	N. 69 W.	5	2	6	.....	.26
.511	.607	.645	.588	S.....	S.....	S.....	12	25	2	13.0	South..	8	4	2	.....	.....
.712	.684	.719	.705	E.....	SW...	Calm..	2	2	0	0.7	S. 17 E	10	10	10	.....	.....
.712	.669	.712	.698	Calm..	W	Calm..	0	4	0	1.3	West...	0	4	0	.....	.12
.794	.597	.816	.736	Calm..	NW ..	NE...	0	2	4	1.7	N. 16 E	7	10	10	.....	.....
.794	.619	.619	.677	N.....	W	W	4	12	25	12.7	N. 84 W.	10	2	0	.....	.60
.747	.563	.244	.518	S.....	SW...	NE...	4	4	4	1.3	South..	0	5	0	.....	.....
.800	.488	.645	.644	NE...	NE...	NE...	12	12	4	9.3	N. 45 E	8	4	7	.....	.....
.800	.521	.577	.633	E.....	W	S.....	2	2	12	4.0	South..	3	10	9	.....	.....
.577	.642	.756	.658	S.....	S.....	S.....	12	4	4	6.7	South..	10	8	10	.....	.....
.819	.859	.727	.785	S.....	NE...	NE...	4	12	25	11.7	N. 59 E	10	10	10	.....	.12
.691	.493	.624	.603	E.....	W	W	12	12	4	1.3	West..	10	4	5	.....	.....
.738	.698	.750	.729	N	NW ..	W	25	4	2	9.3	N.10 W.	0	3	0	.....	.....
.896	.674	.710	.760	NE...	SW ..	Calm..	4	2	0	0.7	N. 45 E	8	9	6	.....	.....
.613	.601	.667	.627	S.....	S.....	S.....	4	25	12	13.7	South..	9	8	6	.....	.....
.750	.710	.677	.712	SW...	SW...	SW...	12	25	2	13.0	S. 45 W.	10	5	6	.....	.24
.829	.744	.816	.796	NE...	NE...	NE...	2	12	4	6.0	N. 45 E.	10	10	10	.....	.....
.800	.765	.698	.754	NW ..	NW ..	W	2	4	2	2.7	N.58 W.	10	10	0	.....	.48
.800	.767	.820	.796	E.....	NE...	S.....	2	2	4	1.3	S. 57 E	10	10	10	.....	.....
.681	.677	.597	.652	SW...	SW...	Calm..	12	4	0	2.0	S. 45 W.	9	4	0	.....	.22
.691	.599	.514	.611	S.....	S.....	S.....	4	12	12	9.3	South..	0	2	1	.....	.....
.704	.669	.794	.722	S.....	SW...	N.....	12	12	12	4.0	S. 45 W.	10	10	0	.....	.12
.775	.533	.719	.676	NE...	N.....	Calm..	2	2	0	1.3	N. 20 E.	0	0	0	.....	.16
.653	.525	.772	.650	S.....	S.....	S.....	4	12	12	9.3	South..	7	10	8	.....	.....
.727	.761	.819	.769	S.....	S.....	S.....	12	12	2	8.7	South..	10	10	10	.....	.08
.734	.651	.692	.692	.....	.....	.....	....	....	....	2.6	S. 38 W.	7.1	6.6	5.7	.....	3.30

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U.S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
May 1	29.207	29.140	29.311	29.219	51	44	40	53	47	43	47.7	58	40	.348	.249	.208	.268
2	29.571	29.751	29.901	29.741	34	36	31	37	40	33	36.7	43	31	.157	.160	.15	.156
3	30.139	30.191	30.116	30.149	29	34	32	31	39	35	35.0	41	25	.137	.131	.142	.137
4	30.112	29.937	29.785	29.945	30	46	45	32	54	53	46.3	57	27	.144	.192	.194	.177
5	29.651	29.578	29.580	29.603	43	50	52	46	54	55	51.7	58	42	.238	.308	.349	.298
6	29.603	29.567	29.555	29.575	51	50	44	54	55	48	52.3	55	44	.335	.295	.236	.289
7	29.573	29.553	29.518	29.548	42	46	43	46	50	46	47.3	50	42	.215	.258	.229	.237
8	29.393	29.174	29.039	29.202	44	44	44	46	47	47	46.7	48	43	.262	.249	.249	.253
9	29.069	29.142	29.228	29.146	42	46	44	45	50	46	47.0	48	41	.228	.258	.228	.241
10	29.418	29.437	29.445	29.430	36	46	44	40	50	48	46.0	51	40	.160	.258	.236	.218
11	29.543	29.545	29.591	29.560	42	48	42	46	52	46	48.0	52	36	.215	.282	.215	.237
12	29.760	29.782	29.755	29.766	42	50	48	45	56	51	50.7	54	34	.228	.282	.296	.235
13	29.770	29.602	29.363	29.578	54	48	45	58	51	47	52.0	56	34	.365	.296	.273	.311
14	29.167	29.212	29.215	29.198	41	45	41	43	49	45	45.7	58	44	.211	.247	.205	.221
15	29.216	29.218	29.231	29.222	42	44	40	44	47	43	44.7	51	41	.241	.249	.206	.232
16	29.388	29.495	29.511	29.461	40	48	42	45	52	46	47.7	59	40	.182	.281	.215	.226
17	29.543	29.562	29.606	29.570	43	47	43	46	51	46	47.7	53	40	.238	.270	.238	.249
18	29.771	29.785	29.765	29.774	46	50	45	50	54	48	50.7	53	43	.258	.308	.260	.275
19	29.836	29.772	29.697	29.768	44	50	47	47	55	50	50.7	53	44	.249	.295	.283	.276
20	29.675	29.617	29.605	29.632	44	58	54	48	64	58	56.7	58	45	.236	.403	.365	.335
21	29.565	29.404	29.272	29.414	48	49	47	50	51	50	50.3	66	39	.309	.321	.283	.304
22	29.227	29.187	29.166	29.193	45	46	42	48	49	44	47.0	60	46	.260	.271	.241	.257
23	29.215	29.262	29.345	29.271	41	46	45	44	50	48	47.3	50	41	.218	.258	.256	.245
24	29.546	29.623	29.615	29.595	50	61	56	54	68	59	60.3	51	39	.308	.443	.409	.387
25	29.667	29.548	29.419	29.545	48	47	46	51	50	48	49.7	70	44	.296	.283	.284	.288
26	29.495	29.532	29.580	29.536	41	49	47	44	53	50	49.0	59	46	.218	.295	.250	.254
27	29.758	29.794	29.765	29.772	41	52	50	46	58	55	53.0	55	41	.192	.309	.295	.265
28	29.837	29.699	29.600	29.712	53	54	52	56	58	55	56.0	61	39	.361	.365	.349	.359
29	29.540	29.562	29.550	29.551	47	48	48	49	51	51	50.3	62	51	.297	.296	.296	.296
30	29.627	29.632	29.575	29.611	44	45	41	46	47	44	45.7	55	47	.262	.273	.218	.251
31	29.700	29.815	29.777	29.764	48	48	46	50	52	49	50.3	55	45	.309	.282	.271	.287
Means....	29.567	29.540	29.546	29.528	43.4	47.6	44.6	46.4	51.7	48.0	48.7	70	25	.248	.280	.258	.262
June 1	29.849	29.792	29.666	29.769	49	59	57	52	64	62	59.3	66	46	.378	.433	.414	.385
2	29.524	29.376	29.314	29.405	59	66	61	65	69	65	66.3	71	58	.420	.599	.480	.501
3	29.253	29.253	29.249	29.252	64	57	53	68	60	56	61.3	70	54	.543	.426	.363	.444
4	29.412	29.518	29.532	29.487	50	55	51	53	60	55	56.0	60	49	.321	.367	.321	.336
5	29.710	29.746	29.659	29.705	48	57	54	51	62.5	58	57.2	64	45	.296	.392	.365	.351
6	29.696	29.620	29.525	29.614	58	68	66	62	76	73	70.3	78	54	.429	.577	.545	.517
7	29.611	29.660	29.668	29.646	61	70	58	67	78	64	69.7	78	54	.457	.625	.443	.495
8	29.762	29.761	29.752	29.758	54	61	61	58	68	66	64.0	72	54	.345	.443	.470	.486
9	29.854	29.866	29.857	29.859	57	66	60	61	73	66	66.7	74	56	.412	.545	.436	.465
10	29.914	29.935	29.854	29.901	59	62	58	64	70	63	65.7	75	53	.433	.449	.416	.433
11	29.901	29.848	29.716	29.822	59	68	63	63	74	68	68.3	75	54	.447	.604	.579	.550
12	29.699	29.701	29.641	29.680	61	62	64	66	66	67	66.3	68	61	.470	.592	.556	.539
13	29.716	29.745	29.746	29.736	58	65	63	61	71	67	66.3	71	56	.443	.537	.522	.501
14	29.797	29.727	29.618	29.714	58	70	70	61	78	76	71.7	81	53	.443	.625	.652	.573
15	29.640	29.579	29.565	29.595	66	72	68	73	81	73	75.7	81	66	.545	.663	.616	.608
16	29.638	29.670	29.701	29.700	66	68	64	70	71	67	69.3	76	64	.586	.644	.556	.595
17	29.774	29.745	29.655	29.725	63	72	70	66	79	77	74.0	82	62	.536	.690	.659	.628
18	29.590	29.603	29.614	29.636	71	64	57	75	67	60	67.3	77	57	.704	.556	.429	.563
19	29.852	29.884	29.817	29.851	53	60	54	57	65	58	60.0	66	53	.350	.451	.367	.389
20	29.887	29.941	29.895	29.908	52	64	58	57	70	62	63.0	70	52	.322	.516	.423	.420
21	29.913	29.908	29.836	29.886	57	69	65	60	75	72	69.0	77	56	.426	.628	.524	.526
22	29.864	29.847	29.751	29.821	60	69	62	66	79	70	71.7	80	56	.438	.574	.449	.487
23	29.771	29.740	29.673	29.728	65	71	65	71	80	72	74.3	81	64	.537	.637	.524	.566
24	29.682	29.639	29.568	29.630	66	72	70	71	81	78	76.7	86	66	.572	.663	.625	.620
25	29.618	29.604	29.625	29.616	66	78	67	70	85	71	75.3	86	67	.586	.863	.648	.699
26	29.591	29.653	29.676	29.640	64	66	65	68	69	69	68.7	72	61	.543	.599	.564	.569
27	29.696	29.675	29.535	29.635	66	70	69	69	78	76	74.3	81	66	.599	.625	.614	.613
28	29.631	29.758	29.769	29.719	62	66	57	66	69	60	65.0	76	58	.502	.599	.436	.508
29	29.825	29.801	29.608	29.745	54	64	60	57	69	64	63.3	70	52	.378	.529	.465	.457
30	29.443	29.342	29.355	29.380	66	70	66	72	77	71	73.3	81	61	.559	.639	.572	.590
Means....	29.704	29.698	29.651	29.684	59.7	66.0	61.9	64.0	72.1	66.9	67.7	86	45	.466	.567	.495	.509

the northern and northwestern lakes at Sackett's Harbor, New York.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.864	.772	.750	.795	NW	NW	W	4	4	4	3.7	N. 60 W.	10	10	6	.....	.15
.712	.645	.800	.719	W	W	W	25	25	4	18.0	West	10	5	0	.....	1.36
.788	.547	.698	.678	N	SW	Calm.	2	4	0	1.0	S. 75 W.	4	5	0	.....	.....
.794	.445	.483	.574	NW	S	SE	2	12	25	5.7	N. 74 W.	9	10	10	.....	.....
.767	.738	.805	.770	S	S	S	12	12	4	9.3	South	10	10	10	.....	.....
.802	.681	.704	.729	S	Calm.	S	2	0	2	1.3	South	10	10	10	.....	.12
.691	.716	.767	.725	S	S	Calm.	2	4	0	2.0	South	10	10	10	.....	.60
.843	.772	.772	.796	NE	NE	NE	4	25	12	13.7	N. 45 E.	10	10	10	.....	.10
.762	.716	.767	.748	NW	SW	SW	2	4	2	2.0	S. 62 W.	10	10	10	.....	.80
.645	.716	.704	.688	SW	SW	SW	4	4	2	3.3	S. 45 W.	10	5	4	.....	.08
.691	.727	.691	.703	SW	SW	NE	2	4	2	1.3	S. 45 W.	5	2	3	.....	.....
.762	.627	.790	.726	NE	W	S	12	12	2	2.3	N. 30 W.	2	7	0	.....	.....
.756	.790	.847	.798	Calm.	S	NE	0	12	4	3.3	S. 16 E.	3	10	10	.....	.....
.833	.710	.684	.742	S	SW	S	12	12	12	11.3	S. 15 W.	10	10	10	.....	.06
.836	.772	.750	.786	S	S	S	12	12	12	12.0	South	10	8	10	.....	.04
.607	.727	.691	.675	S	S	Calm.	2	4	0	2.0	South	10	8	6	.....	.16
.767	.722	.767	.752	S	S	S	2	4	2	2.7	South	10	6	10	.....	.....
.716	.788	.777	.744	N	W	SW	4	4	2	2.0	N. 64 W.	10	5	8	.....	.08
.772	.681	.786	.746	N	W	Calm.	2	4	0	1.7	N. 67 W.	4	5	10	.....	.....
.704	.675	.756	.712	N	N	Calm.	2	2	0	1.3	North	10	10	7	.....	.....
.856	.859	.786	.834	NE	NE	NE	2	4	4	3.3	N. 45 E.	5	9	10	.....	.....
.777	.781	.836	.798	Calm.	SW	S	0	4	2	1.7	S. 29 W.	10	10	10	.....	.44
.756	.716	.777	.750	SW	SW	SW	4	4	25	11.0	S. 45 W.	10	9	10	.....	.38
.738	.647	.819	.735	SW	W	SW	12	12	2	7.0	S. 66 W.	10	8	7	.....	.18
.790	.786	.850	.809	S	S	S	12	25	25	20.7	South	0	5	10	.....	.....
.756	.733	.786	.758	SW	SW	W	4	12	2	6.3	S. 53 W.	10	8	0	.....	.42
.617	.641	.681	.646	SW	SW	Calm.	2	4	0	2.0	S. 45 W.	8	5	5	.....	.08
.809	.756	.805	.790	Calm.	NE	NE	0	4	4	2.7	N. 45 E.	4	10	10	.....	.....
.853	.791	.790	.811	N	SW	SW	2	2	2	1.0	S. 75 W.	10	10	10	.....	.12
.843	.847	.756	.815	SW	SW	W	4	12	12	8.7	S. 64 W.	10	10	10	.....	.....
.856	.727	.781	.788	W	W	W	4	12	2	6.0	West	8	4	0	.....	.....
.767	.717	.755	.746	.....	.....	.....	.....	.....	.....	3.1	S. 42 W.	8.1	7.9	7.3	.....	5.80
.794	.727	.745	.755	S	SW	Calm.	2	2	0	1.3	S. 20 W.	9	8	3	.....	.....
.680	.846	.783	.770	S	S	S	12	4	12	9.3	South.	10	10	10	.....	.....
.793	.822	.809	.808	SW	SW	SW	4	12	12	9.3	S. 45 W.	5	4	2	.....	.34
.798	.708	.743	.750	W	W	W	4	12	4	6.7	West	10	5	0	.....	.04
.790	.694	.756	.747	S	W	SW	2	4	2	2.0	S. 34 W.	1	0	2	.....	.....
.772	.644	.672	.699	S	S	S	4	4	2	3.3	South.	3	4	0	.....	.....
.690	.653	.675	.673	Calm.	NW	NE	0	4	4	1.9	North.	6	6	4	.....	.....
.756	.647	.735	.713	NE	NE	N	4	4	2	3.0	N. 36 E.	8	10	5	.....	.....
.769	.672	.685	.675	NE	NE	Calm.	2	4	0	2.0	N. 45 E.	3	2	3	.....	.....
.727	.613	.723	.688	NE	NE	Calm.	2	4	0	2.0	N. 45 E.	0	4	0	.....	.....
.776	.720	.743	.746	S	S	S	12	12	12	12.0	South	4	6	8	.....	.....
.735	.786	.841	.787	S	S	S	12	4	2	6.0	South	10	10	7	.....	.....
.825	.768	.799	.774	S	W	W	2	4	2	2.3	S. 73 W.	2	5	7	.....	.06
.825	.653	.727	.735	Calm.	SW	S	0	2	12	4.7	S. 6 W.	3	2	7	.....	.....
.672	.627	.761	.687	S	S	S	4	12	4	6.7	South	6	8	10	.....	.....
.799	.850	.841	.830	SW	SW	Calm.	4	2	0	2.0	S. 45 W.	10	10	5	.....	.10
.838	.697	.689	.741	NE	SW	S	2	4	4	2.3	S. 13 W.	10	6	4	.....	.....
.812	.841	.822	.825	S	SW	W	12	12	12	9.7	S. 45 W.	10	8	5	.....	.....
.752	.731	.756	.746	W	W	Calm.	4	12	0	5.3	West	0	0	0	.....	.16
.692	.704	.772	.723	SW	NE	Calm.	2	4	0	0.7	N. 45 E.	7	10	10	.....	.....
.822	.724	.668	.738	NE	W	Calm.	2	2	0	0.7	N. 14 W.	8	4	1	.....	.08
.685	.580	.613	.626	S	SW	S	2	4	2	2.3	S. 24 W.	4	5	2	.....	.....
.708	.623	.668	.666	S	SW	Calm.	12	4	0	5.0	S. 11 W.	0	7	1	.....	.....
.754	.627	.653	.678	S	SW	NE	2	4	4	0.7	South.	2	5	3	.....	.....
.799	.718	.802	.773	NE	SE	S	2	4	2	2.0	S. 55 E.	3	8	4	.....	.....
.793	.816	.796	.812	S	SE	S	4	4	12	6.3	S. 7 E.	10	10	8	.....	.10
.846	.653	.685	.728	S	SW	S	12	4	12	9.0	S. 5 W.	10	6	10	.....	.14
.786	.846	.822	.818	SW	SW	SW	12	25	4	13.7	S. 45 W.	8	6	0	.....	.....
.812	.747	.780	.800	SW	SW	S	4	4	4	3.7	S. 30 W.	0	4	0	.....	.....
.712	.689	.754	.718	S	S	S	25	25	12	20.7	South.	3	8	4	.....	.....
.767	.713	.740	.740	.....	.....	.....	.....	.....	.....	3.9	S. 19 W.	5.5	6.0	4.2	.....	1.02

Reductions of the monthly meteorological register of the survey of

Date.	Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
					Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.					°	°	°	°	°	°	°	°	°				
July 1	29.616	29.648	29.596	29.620	62	68	61	65	72	64	67.0	76	61	.516	.631	.497	.548
2	29.674	29.659	29.498	29.674	56	73	60	60	77	63	66.7	77	56	.396	.757	.478	.544
3	29.618	29.634	29.480	29.577	61	72	70	66	77	75	72.7	86	59	.470	.788	.666	.642
4	29.580	29.491	29.536	29.536	69	.71	62	73	77	66	72.0	78	62	.655	.678	.502	.612
5	29.632	.....	29.495	29.564	59	....	71	62	....	76	69.0	79	59	.460	....	.691	.576
6	29.433	29.394	29.483	29.437	70	77	66	75	81	69	75.0	84	66	.666	.873	.599	.713
7	29.586	29.542	29.583	29.570	63	72	61	65	77	66	69.3	77	61	.549	.718	.470	.579
8	29.774	29.778	29.704	29.752	55	63	60	59	67	63	63.0	69	55	.367	.522	.478	.456
9	29.712	29.739	29.712	29.721	54	59	58	58	61	61	60.0	64	54	.365	.473	.443	.427
10	29.807	29.873	29.698	29.793	51	64	62	54	69	67	63.3	69	51	.335	.529	.489	.450
11	29.631	29.572	29.498	29.567	61	73	68	67	78	71	72.0	79	62	.457	.744	.644	.615
12	29.553	29.676	29.719	29.649	64	62	57	67	66	60	64.3	70	58	.556	.502	.436	.498
13	29.860	29.947	29.906	29.904	50	61	57	54	68	61	61.0	70	48	.308	.443	.412	.388
14	30.012	30.075	29.923	30.003	54	67	63	58	77	68	67.7	78	48	.365	.527	.519	.467
15	.....	.....	29.665	29.665	....	....	64	....	....	73	73.0	79	56	....	....	.476	.476
16	29.653	29.725	29.716	29.698	64	69	62	67	75	65	69.0	76	63	.556	.628	.516	.567
17	29.832	29.865	29.781	29.826	51	66	58	54	78	61	64.3	78	51	.335	.478	.443	.419
18	29.817	29.821	29.816	29.818	54	62	60	58	67	63	62.7	69	54	.365	.489	.578	.477
19	29.823	29.809	29.751	29.794	50	62	61	54	70	66	63.3	72	55	.308	.449	.470	.409
20	29.785	29.675	29.603	29.688	60	67	62	64	75	68	69.0	76	60	.465	.542	.476	.494
21	29.541	29.491	29.446	29.493	61	65	65	66	72	69	69.0	74	55	.470	.524	.564	.519
22	29.459	29.482	29.455	29.465	56	70	67	60	77	71	69.3	80	56	.396	.639	.608	.548
23	29.693	29.657	29.598	29.649	53	76	70	63	82	76	73.3	84	58	.416	.816	.652	.628
24	29.598	29.584	29.505	29.562	69	78	73	74	86	78	79.3	86	70	.641	.850	.744	.778
25	29.513	29.522	29.470	29.502	69	76	71	74	81	75	76.7	81	70	.641	.829	.704	.725
26	29.488	29.505	29.568	29.520	63	72	67	67	79	72	72.7	80	64	.522	.690	.595	.602
27	29.603	29.634	29.489	29.575	59	79	77	65	88	85	79.3	88	58	.420	.868	.819	.736
28	29.507	29.379	29.375	29.420	75	78	74	80	88	78	82.0	88	75	.800	.823	.785	.803
29	29.438	29.562	29.686	29.562	71	70	63	75	76	65	72.0	78	63	.704	.652	.549	.635
30	29.794	.....	29.827	29.810	57	....	61	61	....	64	62.5	73	52	.412	....	.497	.455
31	29.907	29.793	29.693	29.798	51	70	62	55	77	70	67.3	78	52	.321	.639	.449	.470
Means....	29.664	29.662	29.622	29.652	59.7	69.4	63.0	64.0	75.4	70.9	69.3	88	48	.474	.644	.556	.556
Aug. 1	29.701	29.668	29.558	29.642	60	65	66	64	74	71	69.7	75	61	.465	.497	.572	.511
2	29.528	29.538	29.485	29.517	68	71	68	72	75	73	73.3	81	67	.631	.704	.618	.651
3	29.668	29.758	29.768	29.731	63	66	62	66	71	65	67.3	74	62	.536	.572	.516	.541
4	29.814	29.870	29.803	29.829	61	69	67	64	77	69	70.0	77	57	.497	.601	.635	.578
5	29.871	29.919	29.818	29.869	64	69	70	68	78	74	73.3	85	64	.543	.588	.679	.570
6	29.821	29.846	29.770	29.812	66	73	74	72	83	78	77.7	87	67	.559	.677	.785	.674
7	29.839	29.824	29.752	29.805	67	73	70	71	82	75	76.0	86	68	.608	.690	.666	.655
8	29.778	29.783	29.698	29.753	67	75	74	73	85	79	79.0	87	68	.581	.733	.772	.695
9	29.740	29.753	29.675	29.723	67	74	70	73	85	77	78.3	88	69	.581	.691	.639	.637
10	29.680	29.735	29.793	29.736	69	72	63	76	79	70	75.0	79	67	.614	.680	.482	.592
11	29.901	29.875	29.816	29.864	57	65	62	63	78	70	70.3	80	56	.386	.443	.449	.426
12	29.779	29.632	29.472	29.628	55	70	65	60	82	76	72.7	85	55	.367	.572	.470	.470
13	29.413	29.425	29.435	29.426	68	72	67	75	77	72	74.7	77	69	.591	.718	.595	.635
14	29.598	29.704	29.708	29.670	64	69	64	68	75	70	71.0	78	65	.543	.628	.516	.562
15	29.802	29.818	29.751	29.790	56	68	62	60	77	70	69.0	78	56	.396	.564	.449	.470
16	29.718	29.651	29.528	29.632	61	66	67	66	73	72	70.3	74	62	.470	.545	.595	.503
17	29.476	29.505	29.458	29.480	65	69	64	69	75	71	71.7	79	65	.564	.628	.543	.578
18	29.462	29.436	29.455	29.451	68	76	66	74	88	77	79.7	88	66	.604	.524	.492	.540
19	29.579	29.650	29.621	29.617	63	65	63	69	77	70	72.0	77	64	.195	.457	.482	.345
20	29.733	29.767	29.703	29.734	62	74	62	67	80	68	71.7	80	64	.489	.758	.476	.574
21	29.718	29.734	29.661	29.704	59	69	62	63	77	67	69.0	79	60	.447	.601	.489	.512
22	29.684	29.637	29.593	29.638	54	69	65	58	80	72	70.0	80	55	.365	.561	.524	.483
23	29.588	29.532	29.465	29.528	61	70	69	65	79	73	72.3	81	57	.483	.612	.635	.583
24	29.488	29.528	29.621	29.546	66	69	64	72	79	68	73.0	80	62	.559	.574	.543	.559
25	29.809	29.825	29.708	29.781	50	62	57	54	74	65	64.3	75	49	.308	.396	.359	.354
26	29.857	29.805	29.733	29.798	57	66	63	63	80	72	71.7	82	56	.386	.452	.455	.431
27	29.753	29.629	29.542	29.641	62	62	66	70	86	78	78.0	88	65	.449	.235	.478	.387
28	29.453	29.412	29.413	29.426	66	71	68	74	77	74	75.0	78	69	.532	.678	.604	.605
29	29.528	29.580	29.546	29.551	56	61	57	61	70	66	65.7	72	57	.383	.416	.346	.382
30	29.642	29.747	29.830	29.740	53	54	53	57	63	60	60.0	65	52	.350	.298	.310	.319
31	29.861	29.811	29.641	29.771	47	57	59	50	69	65	61.3	72	47	.283	.306	.420	.336
Means....	29.687	29.690	29.639	29.672	61.4	68.1	64.8	66.3	77.6	71.2	71.7	88	47	.476	.561	.535	.524

the northern and northwestern lakes at Sackett's Harbor, New York.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.836	.804	.833	.824	N.....	SW...	S	12	2	2	3.0	N. 9 W.	3	10	2	.....	.....
.765	.817	.831	.804	SE....	SW...	S	2	4	2	2.3	S. 9 W.	0	4	0	.....	.....
.735	.774	.768	.759	S	SW...	S	4	4	2	3.0	S. 18 W.	5	4	0	.....	.....
.807	.731	.786	.775	S	SW...	NE ...	4	4	4	1.3	South ..	7	8	4	.....	.....
.828	.....	.771	.800	NE ...	.....	SE....	12	....	2	4.0	N. 54 E.	10	0	10	.....	.18
.768	.826	.846	.813	S	SW...	S	12	12	2	8.0	S. 21 W.	8	10	7	.....	.....
.890	.774	.735	.800	SW...	SW...	SW...	12	12	12	12.0	S. 45 W.	9	7	0	.....	.80
.708	.790	.831	.780	SW...	SW...	S	4	4	2	3.0	S. 35 W.	3	5	4	.....	.....
.756	.882	.825	.821	S	NE ...	W	4	2	2	1.0	S. 12 W.	10	10	7	.....	.....
.802	.747	.740	.763	Calm..	SW ..	S	0	12	2	4.7	S. 39 W.	0	8	6	.....	.18
.690	.776	.850	.772	S	S	S	25	12	4	13.7	South ..	10	10	8	.....	.....
.841	.786	.822	.816	S	NE ...	NE ...	2	2	12	4.0	N. 49 E.	9	8	2	.....	.20
.738	.647	.769	.718	NE ...	NE ...	Calm..	4	4	0	2.7	N. 45 E.	0	4	0	.....	.....
.756	.569	.743	.689	E	W	Calm..	2	4	0	0.7	West ..	0	2	0	.....	.....
.....	.....	.588	.588	.....	.....	S	.....	.....	12	4.0	South ..	....	....	10	.....	.....
.841	.724	.836	.800	S	W	W	4	12	2	5.0	S. 74 W.	10	7	2	.....	.....
.802	.499	.825	.709	E	SW...	S	2	12	2	4.0	S. 33 W.	0	6	5	.....	.....
.756	.740	.831	.779	NE ...	NE ...	NE	4	12	4	6.7	N. 45 E	10	9	1	.....	.06
.738	.613	.735	.695	NE ...	NE ...	N	2	12	4	5.7	N. 35 E.	4	9	2	.....	.....
.780	.603	.695	.693	NE ...	NE ...	Calm..	12	12	0	8.0	N. 45 E	9	8	3	.....	.....
.735	.668	.796	.733	NE ...	NW ..	Calm..	2	4	0	1.7	N. 16 W.	4	7	8	.....	.....
.765	.689	.802	.752	E	SW...	S	2	12	2	4.0	S. 32 W.	5	7	3	.....	.06
.623	.747	.727	.732	S	S	S	2	12	2	5.3	South ..	0	2	0	.....	.....
.764	.684	.776	.741	S	S	S	4	12	2	6.0	South ..	3	4	0	.....	.....
.764	.784	.812	.787	S	S	Calm..	4	2	0	2.0	South ..	10	10	10	.....	.....
.790	.697	.758	.748	NE ...	NE ...	Calm..	4	4	0	2.7	N. 45 E	10	4	0	.....	.....
.680	.656	.681	.672	S	S	S	4	12	25	13.7	South ..	5	4	6	.....	.....
.782	.622	.819	.741	S	S	S	25	12	4	13.7	South ..	8	7	9	.....	.28
.812	.727	.890	.810	SW...	SW...	NE ...	2	25	2	8.3	S. 45 W.	9	6	0	.....	.08
.769	.....	.833	.534	NE	.....	S	2	....	2	0.7	S. 73 E.	8	....	0	.....	.26
.743	.689	.613	.682	S	S	S	2	12	12	8.7	South ..	5	6	4	.....	.....
.772	.699	.780	.747	.....	.....	.....	....	....	....	0.4	S. 50 W.	6.0	6.8	3.7	.....	2.10
.780	.593	.754	.709	S	S	S	12	25	4	13.7	South ..	9	10	6	.....	.....
.804	.812	.761	.794	S	W	N	4	4	4	1.3	West...	8	6	9	.....	.....
.838	.754	.836	.809	N	W.NW	NW ..	4	2	2	2.3	N. 27 W	10	8	0	.....	.....
.833	.648	.896	.792	S	SW...	S	4	12	2	5.7	S. 30 W.	5	0	3	.....	.....
.793	.613	.810	.739	S	S	S	4	12	2	6.0	South ..	9	3	0	.....	.....
.712	.600	.819	.710	S	S	Calm..	2	4	0	2.0	South ..	6	3	0	.....	.....
.802	.632	.768	.734	S	W.....	Calm..	2	12	0	4.3	S. 81 W.	4	4	0	.....	.....
.716	.609	.779	.701	S	SW...	S	2	12	2	5.0	S. 34 W.	0	7	8	.....	.....
.716	.574	.689	.660	S	S	S	2	4	2	2.7	South ..	0	3	4	.....	.06
.685	.697	.658	.680	S	N	Calm..	4	4	0	...	.....	10	7	0	.....	.....
.670	.463	.613	.582	N	NE ...	S	2	2	2	0.7	S. 45 E.	3	0	0	.....	.22
.708	.524	.524	.585	S	SW...	S	2	4	12	5.7	S. 9 W.	0	8	5	.....	.....
.681	.774	.758	.738	S	S	Calm..	12	25	0	12.3	South ..	10	10	9	.....	.....
.793	.724	.704	.740	NE ...	SW...	Calm..	2	4	0	0.7	S. 45 W.	10	4	3	.....	.18
.765	.608	.613	.662	N	NE ...	NE	2	4	2	2.7	N. 32 E.	9	6	8	.....	.....
.735	.672	.758	.722	NE ...	NE ...	NE	4	4	4	4.0	N. 45 E.	10	10	8	.....	.....
.796	.724	.663	.728	NE ...	N	S	4	2	2	1.3	N. 45 E	10	6	4	.....	.....
.720	.512	.531	.588	SW ..	SW...	S	4	4	12	6.0	S. 19 W.	0	4	10	.....	.....
.700	.493	.658	.617	SW ...	SW...	W	25	25	12	19.7	S. 53 W	8	10	10	.....	.....
.740	.741	.695	.725	W	SW ..	S	4	4	2	2.7	S. 53 W.	10	5	0	.....	.....
.776	.648	.740	.721	S	SW...	SW...	2	12	2	5.0	S. 41 W.	4	3	5	.....	.....
.756	.548	.668	.657	NE ...	SW...	S	2	4	2	1.3	S. 21 W.	5	9	3	.....	.....
.783	.618	.807	.736	Calm..	SW...	S	0	12	2	4.7	S. 39 W.	0	4	0	.....	.....
.712	.580	.793	.695	S	SW...	NE ...	4	12	12	1.3	South ..	9	4	2	.....	.....
.738	.472	.582	.597	E	W	S	2	4	2	1.0	S. 45 W.	0	0	0	.....	.....
.670	.441	.582	.564	S	SW...	S	4	4	2	3.0	S. 18 W.	3	5	0	.....	.....
.613	.189	.499	.434	SW...	SW...	S	4	4	12	6.0	S. 19 W.	4	0	4	.....	.....
.634	.731	.720	.695	S	S	W	25	25	4	17.0	S. 5 W.	8	10	10	.....	.....
.713	.570	.543	.609	NW...	NW...	NW...	4	12	12	9.3	N. 45 W.	3	6	10	.....	.78
.752	.599	.599	.623	NW...	NW...	NW...	12	12	2	9.0	N. 45 W.	8	5	0	.....	.10
.786	.432	.680	.633	S	S	S	4	12	4	6.7	South ..	0	9	10	.....	.....
.739	.597	.693	.676	.....	.....	.....	....	....	....	3.3	S. 29 W	5.7	5.5	4.2	.....	1.34

Reductions of the monthly meteorological register of the survey of

Date.		Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT. Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.						VAPOR. Elasticity, in U.S. inches and decimals.			
		7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.						°	°	°	°	°	°	°	°	°				
Sept	1	29.539	29.542	29.622	29.568	57	57	54	60	59	57	58.7	64	55	.426	.439	.378	.481
	2	29.811	29.833	29.776	29.807	47	58	54	50	64	58	57.3	69	47	.293	.403	.365	.350
	3	29.732	29.738	28.628	29.699	59	69	63.5	63	76	68	69.0	80	54	.447	.614	.536	.532
	4	29.748	24.795	29.744	29.762	58	61	53	61	68	57	62 0	71	55	.443	.443	.350	.412
	5	29.752	29.715	29.569	29 676	48	69	68	50	76	75	67.0	84	47	.309	.614	.591	.505
	6	29.598	29.577	29.698	29.614	64	71	59	70	80	66	72.0	85	58	.5 6	.617	.407	.520
	7	29.917	30.019	30.007	29.981	50	57	53	53	66	59	59.3	69	51	.321	.346	.323	.330
	8	30.078	30.013	29.919	30.003	47	64	64	50	73	71	64.7	75	45	.283	.476	.5 3	.421
	9	29.829	29.700	29.553	29.694	59	70	65	64	79	72	71.7	80	60	.433	.612	.521	.522
	10	29.648	29.746	29.747	29.714	58	53	48	61	59	52	57.3	70	50	.443	.323	.292	.349
	11	29.874	29.869	29.712	29.818	52	56	51	40	63	55	52.7	66	38	.263	.356	.321	.293
	12	29.682	29.663	29.586	29.644	50	62	59	54	71	66	63.7	75	50	.3 8	.436	.407	.384
	13	29.5 4	29.471	25.616	29.530	59	64	53	65	71	54	64.7	72	54	.430	.5 3	.336	.430
	14	29.910	30.026	30.026	29.987	40	47	43	43	55	47	48.3	62	41	.20	.217	.225	.217
	15	30.077	29.991	29.952	30.007	38	61	57	40	71	64	58.3	71	37	.203	.403	.373	.33
	16	29.893	29.883	29.806	29.861	55	67	67.5	59	74	72	68.3	74	55	.389	.568	.6 2	.520
	17	29.989	29.934	29.863	29.929	68	74	73	71	80	78	76.3	83	68	.644	.736	.744	.7 5
	18	29.878	29.791	29.728	29.799	70	75	71	75	83	75	77.7	84	71	.666	.76	.704	.710
	19	29.867	29.938	29 8 9	29.871	58.5	62	57	62	74	62	66.0	75	59	.429	.396	.399	.411
	20	29.678	29.6.7	29.748	29.681	65	75	58	70	85	65	73.3	85	56	.550	.733	.389	.557
	21	29.910	29.93	29.849	29.897	48	59	55	51	67	59	59.0	70	49	.296	.393	.380	.356
	22	29.823	29.714	29.769	29.769	52	60	52	55	64	56	58.3	67	52	.349	.4 5	.335	.283
	23	29.994	30.162	30.129	30.095	39	45	41	41	49	45	45.0	56	39	.212	.247	.205	.221
	24	30.122	30.051	29.759	29.977	35	55	53	37	64	62	54.3	70	35	.178	.314	.284	.259
	25	29.522	29.616	29.7 7	29.615	55	55	47	60	65	52	59.0	65	49	.367	.39	.257	.3
	26	29.909	29.934	29.793	29.879	45	46	42	48	5	45	47.7	56	43	.280	.278	.228	.249
	27	29.798	29.791	29.692	24.757	45	51	47	47	58	50	51.7	61	42	.273	.305	.2 4	.307
	28	29.683	29.666	29.576	29 642	46	54	56	49	59	61	56.3	69	46	.271	.351	.3 1	.335
	29	29 454	29.542	29.634	29.543	55	46	41	6	49	44	51.0	60	42	.367	.271	.2 8	.285
	30	29.853	.....	29.813	29.833	35	....	34	37	..	37	37.0	49	34	.178	....	.157	.16
Means . . .		29.801	29.802	29 761	29.788	51.4	58 2	54.6	54.9	67.0	59.6	60.2	85	34	.356	.449	.416	.395
Oct.	1	29.844	29.656	29.560	29.687	25	53	47	27	60	51	46.0	61	24	.112	.310	.271	.23
	2	29.437	29.322	29.384	29.364	47	58	56	53	64	60	59.0	65	46	.244	.4 3	.386	.34
	3	29.615	29.698	29.697	29.670	43	43	38	46	49	42	45.7	60	40	.258	.199	.177	.20
	4	29.8.6	29.766	29.747	29.783	34	54	45	36	62	52	50.0	63	34	.170	.312	.207	.296
	5	29.517	29.405	29.533	29.485	48	51	43	51	53	45	49.7	59	44	.296	.348	.251	.29
	6	29.867	29.943	29.985	29.932	39	45	39	41	50	44	45.0	52	39	.212	.254	.173	.2 6
	7	30.161	30.247	30.155	30.188	29	41	34	30	47	37	38.0	50	28	.149	.177	.159	.162
	8	30.171	30.164	29.914	30.050	28	48	45	30	58	49	49.0	58	25	.130	.203	.247	.193
	9	29.874	29.667	29.427	29.656	39	47	52	41	54	55	50.0	59	38	.212	.231	.349	.264
	10	29.270	29.272	29.225	29.256	50	53	53	54	56	55	54 7	60	37	.321	.363	.376	.353
	11	29.3 0	29.392	29.425	29.372	47	48	50	50	51	53	51.3	58	47	.283	.296	.321	.300
	12	29.497	29.555	29.586	29.546	48	44	39	50	45	41	45.3	54	39	.3 9	.275	.212	.25
	13	29.664	29.667	29.617	29.649	37	49	52	38	54	54	48.3	56	34	.207	.295	.362	.288
	14	29.707	29.677	29.647	29.677	38	54	46	40	58	49	49.0	59	36	.283	.365	.271	.290
	15	29.585	29.676	29.732	29.664	48	53	45	51	58	48	52.3	61	46	.296	.346	.2	.297
	16	29.902	29.916	29.800	29.873	34	54	52	35	59	57	50.3	64	34	.183	.351	.322	.285
	17	29.747	29.687	29.508	29.647	56	64	60	62	77	68	69.0	77	55	.369	.422	.411	.401
	18	29.579	29.622	29.574	29.592	56	62	57	60	69	61	63.3	70	57	.396	.462	.412	.423
	19	29.690	29.762	29.764	29.739	50	62	61	53	68	62	61.0	70	50	.321	.476	.491	.429
	20	29.874	29.881	29.854	29.873	54	70	62	56	76	67	66.3	76	53	.391	.652	.4 9	.511
	21	29.905	29.841	29.704	29.817	61	66	58	64	75	66	68.3	76	59	.497	.519	.376	.464
	22	29.664	29.739	29.822	29.742	59	52	43	62	56	47	55.0	66	44	.460	.315	.225	.340
	23	30.042	30.173	30.110	30.108	35	40	41	38	45	45	42.7	50	35	.165	.182	.2 5	.184
	24	30.180	30.274	30.173	30.209	36	46	38	38	51	41	43.3	55	35	.186	.245	.190	.207
	25	30.170	30.180	30.097	30.149	34	46	37	36	55	40	43.7	58	34	.170	.192	.181	.181
	26	30.073	30.125	30.014	30.071	31	49	42	31	58	44	44.3	58	30	.174	.229	.241	.215
	27	30.090	30.112	30.042	30.078	36	53	45	38	57	47	47.3	60	36	.186	.350	.273	.270
	28	30.090	.....	29.929	30.010	34	....	48	35	....	51	43.0	56	33	.183	....	.296	.240
	29	29 832	29.717	29.610	29.720	45	52	48	48	57	51	52.0	58	45	.280	.322	.296	.299
	30	29.568	29.473	29 463	29.501	44	49	45	46	54	49	49.7	55	43	.262	.262	.247	.264
	31	29.521	29.658	29.675	29.618	41	46	41	43	50	44	45.7	51	41	.231	.258	.2 8	.236
Means . . .		29.783	29.776	29.733	29.766	42.1	51.7	47.1	44.6	57.5	50.8	50.9	77	24	.252	.321	.287	.288

the northern and northwestern lakes at Sackett's Harbor, New York.

VAPOR.				WIND.								Amount of cloudiness. (0 = clear sky.) (10 = sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.822	.878	.812	.837	S	NE ...	NE ...	4	12	2	3.7	N. 60 E.	10	10	8	.....	.38
.786	.675	.756	.739	NE ...	NE ...	SE....	2	2	2	1.7	N. 74 E.	9	4	0	.....	.08
.776	.685	.768	.743	S	S	S	4	25	12	13.7	South ..	6	8	10	.....	.....
.825	.647	.752	.741	SW ...	SW ...	Calm..	2	4	0	2.0	S. 45 W.	5	0	0	.....	1.10
.856	.685	.681	.741	NE ...	W	S	2	2	12	3.3	S. 5 W .	0	4	3	.....	.....
.704	.623	.636	.654	S	W	NE ...	12	12	4	4.3	N. 45 W.	0	6	9	.....	.....
.298	.543	.647	.663	NE ...	NE ...	Calm .	2	12	0	4.7	N. 45 E	3	4	0	.....	.....
.786	.588	.663	.679	NE ...	W	S	2	4	2	1.0	S. 79 W.	0	3	5	.....	.....
.727	.618	.668	.671	S	S	S	12	25	25	20.7	South ..	0	3	10	.....	.....
.825	.647	.727	.733	NW...	NE ..	Calm..	4	12	0	4.3	N. 26 E	10	10	5	.....	.60
.820	.619	.743	.727	S	SW ..	SW ...	2	4	4	3.0	S. 39 W.	0	4	0	.....	.....
.738	.576	.636	.650	S	SW ...	S	4	12	4	6.3	S. 28 W.	0	0	0	.....	.....
.680	.663	.698	.680	S	S	NE ...	12	25	4	11.7	S. 4 E .	10	10	3	.....	.....
.750	.502	.698	.650	NE ...	NE ...	E	4	4	2	3.0	N. 54 E	0	0	0	.....	.10
.820	.532	.625	.659	E	S	S	2	4	2	2.3	S. 17 E .	6	0	0	.....	.....
.761	.677	.781	.740	S	S	S	4	12	2	6.0	South ..	5	10	10	.....	.....
.850	.741	.776	.789	S	SW ...	Calm..	2	4	0	1.7	S. 34 W.	9	4	0	.....	.06
.768	.673	.812	.751	S	S	S	2	4	4	3.3	South ..	8	7	10	.....	.....
.800	.472	.718	.663	NE ...	NE ...	Calm..	12	4	0	5.3	S. 45 E	3	4	0	.....	.12
.751	.609	.631	.664	S	S	N	12	25	12	8.3	South ..	2	8	5	.....	.....
.790	.595	.761	.715	Calm..	W	Calm..	0	2	0	0.7	West ..	8	4	0	.....	.....
.805	.780	.747	.777	S	SW ...	NE ...	2	12	12	0.7	South ..	10	10	6	.....	.....
.824	.710	.684	.739	NE ...	NE ...	Calm..	12	4	0	5.3	S. 45 E.	4	0	0	.....	.10
.807	.527	.511	.615	E	S	S	2	12	25	12 7	S. 3 E	0	4	0	.....	.....
.708	.487	.760	.618	S	NW...	NE ...	25	25	12	3.3	N. 83 W.	8	10	8	.....	.....
.777	.716	.762	.752	NE ...	NE ...	Calm..	4	4	0	2.7	N. 45 E	10	9	0	.....	.20
.847	.756	.786	.796	S	SW ...	S	2	12	2	5.0	S. 34 W	4	5	0	.....	.....
.781	.703	7 3	.742	S	S	S	2	2	2	2.0	South ..	2	4	0	.....	.....
.708	.781	.756	.748	S	NE ..	NE ...	4	12	12	7.3	N. 53 E .	0	10	10	.....	.....
.807	.....	.712	.760	NE ..	NE ...	Calm..	12	12	0	8.0	N. 45 E	4	10	0	.....	.10
.773	.642	.711	.714	.....	.....	.....	...	...	...	2.9	N. 12 E	4.7	5.5	3.4	....	2.84
.761	.599	.722	.694	E	W	S	2	12	2	3.7	S. 79 W.	0	5	3	.....	.....
.606	.675	.765	.682	S	S	W	4	12	12	6.7	S. 37 W.	8	10	6	.....	.....
.767	.572	.661	.667	N	N	Calm..	2	2	0	1.3	North ..	4	2	0	.....	.08
.802	.561	.545	.633	S	SW ...	SE ...	2	4	2	2.3	S 11 W .	2	3	10	.....	.....
.790	.864	.840	.831	SE....	SE....	NW ...	4	12	12	1.3	S. 45 E	10	10	10	.....	1.20
.824	.686	.597	.689	NW...	NW...	N	4	4	2	3.0	N. 36 W.	10	7	0	.....	.30
.890	.554	.712	.719	Calm..	NE ...	Calm..	0	4	0	1.3	N. 45 E	0	0	0	.....	.....
.782	.421	.710	.638	S	S	Calm..	2	4	0	2.0	South ..	1	0	9	.....	.....
.824	.552	.805	.727	E	E	SW ...	2	2	12	3.3	S. 27 W	10	10	10	.....	.....
.798	.809	.869	.825	S	S	S	12	12	2	8.7	South ..	10	10	8	.....	.10
.786	.790	.798	.791	SE....	NE ...	E	2	4	2	6.7	N. 45 E	10	10	10	.....	.08
.856	.920	.824	.867	NE ...	NE ...	NE ...	4	12	4	2.0	West ...	10	10	6	.....	.06
.905	.743	.867	.835	E	W	W	2	4	4	1.0	S. 45 W	9	4	0	.....	.04
.820	.756	.781	.786	E	W	S	2	4	2	8.0	South ..	0	4	5	.....	.....
.790	.698	.777	.755	S	S	Calm..	12	12	0	4.7	S. 3 W..	10	6	0	.....	.....
.898	.703	.692	.764	E	SW ...	S	2	4	12	12.0	South ..	0	5	2	.....	.....
.665	.456	.601	.574	S	S	S	12	12	12	2.7	South ..	5	8	10	.....	.....
.765	.653	.769	.729	S	S	S	2	4	2	2.0	South ..	8	0	0	.....	.....
.798	.695	.884	.792	S	S	Calm..	2	4	0	0.7	N. 21 W.	5	4	0	.....	.....
.872	.727	.740	.780	NE	W	Calm..	2	2	0	9.3	South ..	2	0	0	.....	.....
.833	.593	.588	.673	S	S	S	4	12	12	1.7	North...	3	0	0	.....	.....
.828	.747	.698	.758	S	NE ...	NW .	12	12	12	2.3	N. 11 E	10	10	8	.....	.14
.719	.667	.684	.670	NW...	NE ...	N	2	4	2	1.7	S. 16 W.	9	3	5	.....	.08
.811	.653	.736	.734	SE....	SW ...	Calm..	2	4	0	1.3	South ..	2	4	0	.....	.....
.802	.445	.742	.660	S	S	Calm..	2	2	0	1.7	S. 16 W	9	5	0	.....	.....
1.000	.475	.836	.704	SE....	SW ...	Calm..	2	4	0	0.9	South ..	2	4	0	.....	.....
.811	.752	.847	.803	SE....	SW ...	Calm..	2	2	0	0.0	Calm ...	0	0	0	.....	.....
.898	.....	.790	.844	Calm..	.....	Calm..	0	....	0	9.3	N. 45 E	8	....	10	.....	.....
.777	.692	.790	.753	NE ...	NE ...	NE ...	4	12	12	5.3	N. 45 E	10	9	7	.....	.....
.843	.674	.710	.742	NE ...	NE ...	Calm..	4	12	0	4.7	N. 45 E	10	8	0	.....	.....
.833	.716	.756	.768	Calm..	NE ...	NE ..	0	12	2	4.7	N. 45 E	3	7	10	....	.....
.811	.658	.746	.735	.....	.....	.....	...	....	....	1.3	S. 8 E..	5.8	5.3	4.2	.....	2.08

Reductions of the monthly meteorological register of the survey of

Date.		Barometer reduced to temperature of 32° Fahr., expressed in United States inches and decimals.				TEMPERATURE—FAHRENHEIT.								VAPOR.			
						Wet bulb, or point of evaporation.			Dry bulb, or temperature of the open air.					Elasticity, in U. S. inches and decimals.			
		7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Mean.	Maximum.	Minimum.	7 a. m.	2 p. m.	9 p. m.	Mean.
1867.						°	°	°	°	°	°	°	°	°				
Nov.	1	29.786	29.593	29.295	29.558	30	44	48	31	48	54	44.3	55	30	.155	.236	.256	.216
	2	29.213	29.292	29.447	29.317	50	53	42	54	60	48	54.0	61	44	.306	.316	.189	.270
	3	29.648	29.348	29.119	29.372	34	41	50	36	41	50	42.3	51	34	.179	.257	.361	.265
	4	29.368	29.583	29.723	29.558	41	39	37	45	44	40	43.0	56	38	.205	.173	.131	.169
	5	29.961	29.858	29.766	29.862	34	39	40	37	45	42	41.3	48	34	.157	.160	.221	.179
	6	29.949	29.968	30.014	29.977	28	30	24	29	33	25	29.0	43	24	.142	.132	.117	.130
	7	30.041	29.844	29.752	29.879	15	33	32	16	38	34	29.3	41	13	.074	.123	.155	.117
	8	29.632	29.525	29.493	29.550	35	52	51	37	60	56	51.0	60	31	.178	.282	.308	.256
	9	29.425	29.520	29.575	29.507	54	55	47	60	60	52	57.3	63	45	.338	.367	.257	.301
	10	29.731	29.682	29.620	29.678	46	48	47	49	55	52	52.0	57	46	.271	.243	.257	.257
	11	29.703	29.668	29.648	29.673	38	41	35	42	45	37	41.3	52	35	.177	.205	.178	.187
	12	29.644	29.575	29.585	29.601	26	35	30	27	38	32	32.3	40	26	.129	.165	.144	.146
	13	29.550	.....	29.542	29.546	24	....	26	25	....	28	26.5	36	24	.117	....	.117	.117
	14	29.320	29.191	29.523	29.345	29	39	29	30	40	31	34.7	45	26	.149	.186	.137	.157
	15	29.864	29.924	29.697	29.828	22	26	28	24	29	30	27.7	33	22	.095	.106	.130	.110
	16	29.317	29.456	29.635	29.469	31	34	24	33	36	25	31.3	40	25	.151	.170	.117	.146
	17	29.585	29.385	29.493	29.488	19	23	19	20	25	21	22.0	28	19	.092	.100	.089	.091
	18	29.736	29.730	29.731	29.732	9	18	17	10	20	18	16.0	24	9	.054	.076	.083	.071
	19	29.899	29.912	29.857	29.889	9	20	27	11	22	29	20.7	31	8	.043	.085	.124	.084
	20	29.745	29.615	29.760	29.707	27	32	31	28	34	33	31.7	42	24	.136	.155	.151	.147
	21	29.980	29.949	29.860	29.928	25	29	22	26	31	24	27.0	35	22	.123	.137	.095	.118
	22	29.795	29.742	29.716	29.751	33	41	41	36	44	45	41.7	46	20	.149	.218	.205	.191
	23	29.766	29.773	29.776	29.772	43	48	46	46	51	48	48.3	52	43	.238	.296	.284	.273
	24	29.850	29.643	29.705	29.769	42	51	50	43	54	53	50.0	55	40	.254	.335	.321	.303
	25	29.735	29.593	29.503	29.610	50	51	51	52	55	53	53.3	56	50	.334	.321	.349	.334
	26	29.503	29.678	29.856	29.679	42	36	33	45	38	35	39.3	53	33	.228	.186	.162	.192
	27	29.954	29.832	29.709	29.832	31	34	35	33	36	37	35.3	38	31	.151	.170	.178	.166
	28	29.676	29.712	29.729	29.706	36	41	35	38	42	38	39.3	43	36	.186	.244	.165	.198
	29	29.556	29.330	29.766	29.551	36	41	45	38	42	47	42.3	48	36	.186	.244	.273	.234
	30	29.328	29.585	29.735	29.549	15	11	11	16	13	13	14.0	44	8	.074	.049	.049	.057
Means....		29.675	29.642	29.654	26.656	31.8	37.4	35.1	33.9	40.8	37.7	37.3	63	8	.169	.185	.186	.183
Dec.	1	30.001	29.935	29.868	29.935	1	17	21	3	19	23	15.0	24	0	.023	.071	.080	.061
	2	29.788	29.647	29.624	29.686	22	20	34	21	28	36	29.3	36	20	.095	.117	.170	.127
	3	29.712	29.610	29.422	29.581	31	32.5	28	33	35	30	32.7	38	28	.151	.151	.130	.144
	4	29.667	29.556	29.421	29.548	0	12	13.5	1	14	16	10.3	30	-4	.032	.052	.052	.045
	5	29.404	29.388	29.618	29.470	15	25	19.5	17	27	21	21.7	29	14	.063	.112	.089	.088
	6	29.556	29.130	28.910	29.199	18.5	32	38	21	33.5	41	31.8	41	10	.073	.162	.190	.108
	7	29.418	29.484	29.565	29.489	26	32	15	28	34	17	26.3	40	15	.117	.155	.063	.112
	8	29.651	29.742	29.771	29.721	8.5	8	3	10	9.5	4	07.8	18	3	.046	.045	.038	.043
	9	29.986	29.949	29.689	29.875	-5	0	6.5	-7	1	8	00.7	15	-12	.006	.032	.042	.027
	10	29.323	29.607	29.611	29.514	24	13	1	26	14	3	14.3	27	0	.106	.067	.023	.065
	11	29.639	29.679	29.845	29.721	6	8	-5	7	10	-3	04.7	12	-8	.046	.040	.012	.033
	12	29.950	29.869	29.882	29.900	-15	-9	-7.5	-13	-8	-6	-9.0	-8	-19	.....	.017	.015	.016
	13	29.955	29.952	29.980	29.962	-12	-4.5	-8	-10	-3	-7	-6.7	-1	-17	.....	.025	.018	.022
	14	30.005	29.918	29.858	29.927	13.5	3.5	0	-11	5	2	-1.3	6	-18	.....	.034	.021	.028
	15	29.773	29.702	29.639	29.705	1	12	7	2	14	8	08.0	15	-5	.034	.052	.048	.045
	16	29.592	29.562	29.514	29.556	2	19.5	6	4	22	8	11.3	26	1	.025	.077	.034	.045
	17	29.458	29.313	29.465	29.412	14	18.5	12.5	16	21	14	17.0	22	4	.059	.078	.059	.065
	18	29.729	29.836	30.012	29.859	-2	10.5	-4	-1	12	-3	02.7	16	-6	.028	.052	.025	.035
	19	30.236	30.266	30.221	30.241	13.5	9	-1	-11	11.5	0	00.2	10	-17	....	.037	.030	.034
	20	29.984	29.615	29.820	29.740	14	22	31	16	25	33	24.7	34	-2	.059	.084	.151	.098
	21	30.105	30.115	29.899	30.040	30	30	26	31	32	28	30.3	35	26	.155	.144	.117	.139
	22	29.284	29.053	29.188	28.175	36	41	33	38	44	37	39.7	45	26	.186	.218	.136	.180
	23	29.397	29.670	29.942	29.670	23	16	15	25	18	17	20.0	37	15	.100	.067	.063	.077
	24	29.873	29.640	29.745	29.753	19	27	34	21	29	36	28.7	37	9	.080	.124	.170	.125
	25	29.882	29.586	29.294	29.587	25	31	40	27	32	44	34.3	45	22	.112	.162	.195	.156
	26	29.487	29.624	29.751	29.621	34	37	32	37	40	33	36.7	46	32	.157	.181	.168	.169
	27	29.354	29.172	29.181	29.236	37	41	42	41	45	44	43.3	49	31	.168	.205	.241	.205
	28	29.647	29.748	29.735	29.710	31	22	21	32	24	23	26.3	44	20	.162	.095	.080	.112
	29	29.793	29.866	29.961	29.873	25	24	18	27	27	20	24.7	33	18	.112	.095	.076	.094
	30	30.113	30.173	30.225	30.170	12	13	0	13	15	2	10.0	22	0	.063	.056	.021	.047
	31	30.270	30.157	29.991	30.139	3	20	15	5	23	17	15.0	27	-5	.027	.074	.063	.055
Means....		29.737	29.696	29.698	29.710	14.5	19.0	15.7	14.6	21.1	17.0	17.6	49	-19	.085	.093	.085	.088

the northern and northwestern lakes at Sacket's Harbor, New York.

VAPOR.				WIND.								Amount of cloudiness. (0=clear sky.) (10=sky entirely overcast.)			Amount of evaporation, in U. S. inches and decimals.	Amount of rain or melted snow, in U. S. inches and decimals.
Humidity. Saturation = 1,000.				Direction. From whence.			Velocity, in miles, per hour.			Resultant velocity, in miles, per hour.	Resultant direction.					
7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.			7 a. m.	2 p. m.	9 p. m.		
											°					
.893	.704	.613	.737	E.....	S.....	S.....	2	12	12	8.3	S. 5 E..	6	10	10	.....	.....
.738	.599	.563	.633	S.....	W.....	W.....	12	25	12	13.0	S. 72 W	6	8	2	.....	.....
.802	1.000	1.000	.934	NE...	NE...	SW...	4	4	25	5.7	S. 45 W	10	10	10	.....	.....
.684	.597	.732	.671	W.....	W.....	W.....	25	12	4	13.7	West...	10	5	7	.....	.16
.712	.533	.829	.691	NW..	W.....	W.....	4	12	12	9.0	N. 84 W	6	9	8	.....	.....
.887	.703	.872	.821	N.....	NW...	N.....	4	4	4	3.7	N. 15 W	6	9	3	.....	.08
.829	.537	.792	.719	NE...	NE...	E.....	2	2	2	1.6	East ..	9	7	4	.....	.....
.807	.546	.687	.680	S.....	S.....	S.....	2	12	4	6.0	South..	4	4	9	.....	.....
.653	.708	.660	.671	S.....	S.....	S.....	12	12	4	9.3	South..	9	10	7	.....	.....
.781	.561	.660	.667	S.....	S.....	SW...	4	4	2	3.3	S. 8 W.	4	10	7	.....	.....
.661	.684	.807	.717	S.....	SW...	SE...	4	2	2	2.3	South..	8	10	10	.....	.....
.880	.719	.794	.798	Calm..	NW...	NW...	0	4	4	2.7	N. 45 W	10	9	9	.....	.08
.872	.....	.768	.820	NW..	.....	NW...	4	....	2	2.0	N. 45 W	10	....	8	.....	.....
.890	.669	.788	.782	S.....	W.....	N.....	4	12	4	4.0	West..	10	9	10	.....	.....
.738	.665	.782	.728	N.....	W.....	S.....	4	4	12	3.0	S. 27 W	10	10	10	.....	.....
.800	.802	.872	.801	S.....	W.....	N.....	12	12	12	4.0	West..	9	10	10	.....	.10
.850	.746	.712	.769	NE...	NE...	N.....	2	2	4	2.3	N. 21 E	10	10	10	.....	.....
.791	.702	.840	.778	NW...	NW...	NW...	4	2	4	3.3	N. 45 W	6	4	3	.....	.06
.596	.721	.775	.697	NW...	W.....	SW...	4	4	2	3.0	N. 81 W	4	3	8	.....	.....
.883	.792	.800	.825	S.....	S.....	W.....	4	12	4	4.0	South..	10	10	10	.....	.....
.876	.788	.738	.801	NE...	NE...	NE...	4	4	2	3.3	N. 45 E	10	3	0	.....	.....
.705	.756	.684	.715	S.....	S.....	S.....	4	12	4	6.7	South..	10	10	10	.....	.....
.767	.790	.850	.802	S.....	S.....	S.....	2	4	2	2.7	South..	10	10	10	.....	.04
.916	.802	.798	.839	S.....	S.....	S.....	2	4	12	6.0	South..	8	7	10	.....	.....
.861	.743	.864	.823	S.....	S.....	S.....	4	12	4	6.7	South..	10	10	10	.....	.....
.762	.811	.797	.790	SW...	SW...	NW..	12	12	2	8.0	S. 50 W	10	10	10	.....	.72
.800	.802	.807	.803	NW..	Calm..	Calm..	2	0	0	0.7	N. 45 W	10	10	10	.....	.....
.811	.914	.719	.815	S.....	SW..	SE...	2	2	2	1.6	South..	10	9	10	.....	.04
.811	.914	.847	.857	SE...	S.....	SW...	2	12	12	7.7	S. 8 W.	10	10	10	.....	.....
.829	.623	.623	.692	NW..	NW...	NW..	12	12	12	12.0	N. 45 W	10	10	7	.....	.50
.796	.721	.769	.763	.....	.....	.....	....	....	....	29	S. 51 W	8.5	8.5	7.8	.....	1.78
.460	.692	.730	.627	NE...	S.....	S.....	2	4	4	2.3	S. 11 E	10	10	7	.....	.....
.738	.768	.802	.769	S.....	S.....	W.....	4	4	12	5.0	S. 57 W	10	10	10	.....	.....
.800	.747	.782	.776	W.....	SW...	NW..	12	12	12	9.7	West...	10	10	10	.....	.06
.707	.635	.575	.639	N.....	SE...	S.....	2	2	2	0.7	S. 45 E	2	10	10	.....	.....
.671	.761	.763	.738	S.....	SW...	W.....	2	2	4	2.0	S. 56 W	9	6	4	.....	.14
.641	.841	.738	.740	S.....	S.....	S.....	4	25	35	21.3	South..	10	10	10	.....	.....
.768	.792	.671	.744	W.....	NW...	NE...	25	4	4	8.7	N. 77 W	5	6	10	.....	.08
.687	.682	.710	.703	N.....	NE...	NE...	2	2	4	2.7	N. 32 E	10	10	9	.....	.....
.191	.710	.665	.522	NE...	N.....	S.....	2	2	2	0.7	N. 45 E	4	10	10	.....	.....
.754	.816	.460	.677	W.....	E.....	Calm..	4	2	0	0.7	West..	10	4	0	.....	.10
.769	.582	.317	.556	Calm..	N.....	N.....	0	4	4	2.7	North..	10	9	6	.....	.....
.....	.577	.442	.510	N.....	N.....	N.....	12	12	12	12.0	North..	10	10	8	.....	.04
.....	.658	.594	.626	NE...	NE...	NE...	4	4	2	3.3	N. 45 E.	0	0	0	.....	.....
.....	.625	.438	.532	NE...	NE...	NE...	2	2	4	2.7	N. 45 E.	10	9	5	.....	.....
.718	.635	.777	.710	N.....	N.....	N.....	2	2	2	2.0	North..	8	10	10	.....	.....
.480	.652	.553	.562	Calm..	Calm..	Calm..	0	0	0	0.0	Calm..	5	0	0	.....	.....
.659	.707	.723	.697	Calm..	Calm..	N.....	0	0	2	0.7	North..	10	10	0	.....	.....
.683	.706	.658	.682	E.....	E.....	Calm..	2	2	0	1.3	East ...	4	6	0	.....	.....
.....	.505	.695	.600	Calm..	Calm..	NE...	0	0	2	0.7	N. 45 E.	1	2	0	.....	.....
.659	.622	.800	.694	S.....	S.....	S.....	12	25	12	16.3	South..	10	10	10	.....	.....
.893	.794	.768	.818	W.....	W.....	N.....	4	2	2	2.3	N. 73 W	10	9	10	.....	.04
.811	.756	.619	.729	S.....	S.....	SW...	25	25	25	23.3	S. 15 W	10	10	10	.....	.38
.746	.682	.671	.700	W.....	NW...	NW...	25	12	2	12.0	N. 74 W	10	5	0	.....	.....
.712	.775	.802	.763	S.....	S.....	S.....	4	25	12	13.7	South..	10	10	10	.....	.....
.761	.696	.677	.778	NE...	N.....	S.....	4	2	2	1.3	N. 45 E	10	10	10	.....	.....
.712	.732	.893	.779	SW...	SW'...	SW...	12	12	2	8.7	S. 45 W	10	4	2	.....	.36
.653	.684	.836	.724	S.....	S.....	S.....	25	25	4	18.0	South..	10	10	10	.....	.....
.896	.738	.730	.788	W.....	NE...	Calm..	4	2	2	1.0	N. 62 W	8	4	10	.....	.34
.761	.644	.702	.702	W.....	W.....	W.....	12	4	4	6.7	West..	10	4	6	.....	.....
.810	.648	.438	.632	N.....	N.....	Calm..	2	4	0	2.0	North..	7	9	1	.....	.....
.500	.598	.671	.590	S.....	SW...	NE...	2	2	2	0.7	South..	2	4	6	.....	.....
.690	.699	.669	.681	.....	.....	.....	....	....	....	2.8	S. 34 W	7.9	7.5	6.3	.....	1.52

APPENDIX W.

REPORT ON THE SURVEY OF THE NORTHERN AND NORTHWESTERN LAKES.

Return of charts issued at Detroit and Buffalo from July 1, 1867, to July 1, 1868.

Month.	Lake Erie.	West end of Lake Erie.	Kelly's and Rase islands.	Straits of Mackinac.	East Nerbish Rapids.	Head of Green Bay.	Saginaw River.	St. Clair Flats.	Buffalo harbor.	Tawas harbor.	Beaver Group.	Eagle harbor.	Agate harbor.	River Ste. Marie, No. 1.	River Ste. Marie, No. 2.	Manmee Bay.	Eagle River.	Ontonagon harbor.	Saginaw Bay.	Thunder Bay.	Marquette harbor.	Presque Isle and Middle Island.	Lake Huron.	South end of Lake Huron.	Grand Island.	West end of Lake Superior.	Grand and Little Traverse Bays.	North end of Green Bay.	Copper harbor.	L'Anse and Keweenaw Bay.	Portage Lake.	Total in each month.
1867.																																
July	29	23	29	25	21	14	...	28	29	27	26	21	22	22	23	27	23	23	30	30	25	30	31	29	29	31	35	36	33	37	37	827
August	20	21	21	20	18	14	11	20	21	21	20	18	18	18	18	20	18	18	21	21	18	19	21	21	19	18	11	11	18	15	15	563
September	40	39	35	33	27	32	33	37	41	36	32	25	25	26	27	37	26	26	39	37	25	35	34	36	21	22	32	35	23	23	24	963
October	18	18	9	14	14	17	24	18	19	17	15	15	15	15	15	18	15	16	22	19	14	21	19	20	18	13	21	28	19	19	19	544
November	17	28	25	23	19	23	24	24	20	25	24	18	18	18	18	26	18	19	26	26	18	25	28	23	21	21	20	21	21	21	21	679
December	....	....	....	1	1	....	....	....	....	....	....	....	....	1	1	....	....	....	....	....	....	....	....	....	....	....	1	1	....	....	....	6
1868.																																
January	2	2	2	1	1	1	1	2	1	1	1	1	1	1	1	2	1	1	2	2	1	2	2	2	1	2	3	3	2	2	3	50
February	3	2	2	3	2	3	3	2	2	2	3	2	2	2	2	2	2	2	3	3	2	3	3	2	2	2	5	5	3	3	3	80
March	10	10	11	12	9	11	11	10	6	8	10	9	9	10	10	10	9	10	10	8	10	8	9	9	11	14	16	19	16	17	19	342
April	21	23	20	20	19	20	32	22	14	21	23	19	21	19	16	23	22	18	26	26	16	24	27	25	23	28	38	39	25	33	32	735
May	26	21	23	25	22	25	24	24	16	22	25	21	18	17	17	21	19	17	22	21	17	18	20	19	27	28	33	32	20	27	22	689
June	29	27	28	26	25	30	32	29	27	29	27	25	25	25	25	27	25	25	32	30	25	31	32	30	32	33	26	27	30	30	30	876
Totals of each	215	216	205	205	178	190	195	216	198	209	206	174	174	174	173	213	178	175	233	223	171	216	226	210	204	212	241	257	210	227	224	6,334

Table showing the annual issue prior to July 1, 1868.

Prior to October 1, 1857	2,500
October 1, 1857, to October 1, 1858	1,675
October 1, 1858, to October 1, 1859	2,600
October 1, 1859, to October 1, 1860	4,890
October 1, 1860, to October 1, 1861	3,254
October 1, 1861, to October 1, 1862	5,245
October 1, 1862, to October 1, 1863	4,084
October 1, 1863, to October 1, 1864	3,283
October 1, 1864, to October 1, 1865	2,589
October 1, 1865, to October 1, 1866	2,082
July 1, 1866, to July 1, 1867	5,464
July 1, 1867, to July 1, 1868	6,354
Total to July 1, 1868	44,020

APPENDIX X.

FORT POINT, SAN FRANCISCO HARBOR,
December 10, 1867.

GENERAL: In answer to department letter of the 31st October, directing me to submit a project or projects for the survey and exploration of the Colorado of the West, especially of those unexplored portions lying between the Mormon settlement of Callville and the junction of the Green and Grand rivers, as well as for the exploration of the lower portions of Green River, I have the honor to submit the following:

The subject of explorations in general being entirely new to me, I would state that since the receipt of the above I have devoted considerable attention to acquainting myself with the details of such published explanations as I have had access to, especially of the report of Lieutenant Ives, who ascended the Colorado River in 1858 to near its great bend. I have sought and obtained information from various parties in San Francisco, who are interested more or less in having the river opened to navigation, and all seem willing and anxious to give all the information they possess, especially the parties who have heretofore been so opposed to a knowledge of the river being made public. The reason is obvious.

Ex-Governor Goodwin, of Arizona, has been particularly kind in pointing out sources of information, as well as in imparting his own views, and I believe that I am now possessed of all the facts concerning the navigability of the Colorado River, so far as known at the present time.

I have no doubt but that light-draught steamers can run up to Callville with little trouble at nearly all seasons of the year. Captain Rodgers, who has been on the river four years, and some 12 years on our western rivers, (the Ohio and Missouri,) took the steamer Esmeralda, 97 feet long, and 22 feet wide, drawing three and a half feet water, to Callville with little trouble in October, 1866. He tells me he could have carried six feet water at that time, but a boat for the purpose should not draw over 18 inches. The river is free from rocks and snags, and the great difficulty of navigating the river is in rounding its sharp turns when the water is rising. The rapids are very short. The most difficult one, Roaring Rapids, he ascended in seven minutes, and thinks they are navigable the whole year round, save perhaps at the time of rising water, which begins about the 1st of May. It rises very rapidly by the middle of June, and begins to subside about the 1st of July. This, I am informed, has been observed for the last five years. The width of the river at Hardyville, where the banks are quite steep, is about 250 yards, and the water rises about 25 feet. The new navigation company, of which Mr. Sneath is the president, is now building a steamer to run between the mouth of the river and Callville, of the following dimensions: length 155 feet, breadth 31 feet, cylinders 18 feet, with 5-foot stroke, and 20-foot wheel at stern, of a capacity of 260 tons. It is expected this boat will be running on the river early next season.

Above Callville, for several hundred miles, the river is entirely unknown, and Callville should be the starting point of the expedition destined to explore this unknown region. For the survey of the river I would recommend the employment of a small steamer, to draw between 12 and 15 inches. Such a boat should be about 110 feet long, by 26 feet wide; and I am of opinion it should be built of wood, instead of iron, as recommended by Lieutenant Ives, for it would be subject to hard blows, and could be more easily repaired. In an iron hull the seams will open, laps will start, and rust take such a hold as to make it almost impossible to

keep her tight. A powerful engine should be put in her, furnished with poppet valves instead of the usual sliding valves, which would be so easily put out of order by the fine silicious sand which the water of the Colorado holds in suspension, and flue boilers instead of tubular boilers.

I should say such a steamer would cost here not far from $30,000, complete, and should be supplied with all the appliances that could be foreseen to be necessary, such as lines, anchors, ring-bolts, &c., for ascending the rapids and rounding the sharp turns. Light skiffs and canvas boats should be carried along, enough for the whole party, so that the expedition may be continued in them beyond the highest point the steamer may be able to reach, or in the event of her being disabled by sunken rocks, or other accident.

In the event of the exploration being ordered, and in the further event of my being directed to take charge of it, I should like to have authority to select the commanding officer of the escort from the subalterns of the corps at present on duty with company D. This escort should be carefully selected with a view to individual qualifications, for besides acting as escort, they would furnish boatmen, carpenters, teamsters, &c., and thus lessen the expense, as well as the size of the expedition. It should number about thirty men, and be armed with the Spencer rifle, to be as effective as possible.

Captain Rodgers thinks the party should enter the cañon above Callville about the 1st of August, soon after the fall of the water at Mohave, and Mr. Adams, with whom I have freely conversed, coincides in this view. My impression is, that early in the fall would be a better time than in December, when the river is at its lowest stage; the river can then be reviewed at a lower stage, and perhaps a more favorable one, on the return of the steamer.

I would advise that it be left to the discretion of the officer in charge to detach a portion of the party, if found necessary, to go by land above Callville, making as frequent communication with the party upon the river as circumstances and the nature of the country will admit; a knowledge of the adjacent country may then be obtained, and the expedition should be provided with a number of pack-saddles or light wagons for the purpose.

The report of the Mormons to Mr. Adams that the river for 200 miles above Callville is better than the 100 miles just below, there is no reason to doubt, and it may be necessary to make a small portage near or around the great bend, and strike the river opposite St. George or Virgin City. I think there will be little difficulty in obtaining animals from the Mormon settlements in the valley of the Virgin, and the river is accessible opposite St. George at about 70 miles distant.

Mr. Adams started for the Colorado River on the 5th instant, and promised to keep me informed of everything of interest connected with this subject. He will endeavor to see the party that came down the river through the great cañon in the fall of 1866, and was picked up, more dead than alive, at Callville. His story is that he started down the river on a raft, with three companions, one of whom was killed by the Indians, and the other two washed overboard.

Captain Stansbury, in his report on the survey of Salt Lake, states that the Green River, when he crossed it in August, 1849, near Fort Bridger, is a fine, bold, clear stream, discharging a large quantity of water. In view of the above facts, it would appear that the best plan for the exploration of this river would be the one proposed herein.

As so much depends upon the character of the expedition, if it is to be merely a military reconnoissance or a more careful geographic or

scientific survey, data, upon which depends, to a great extent, the time necessary for its completion, and having such a bearing upon its cost, render it quite impossible for me to make a satisfactory estimate. I would recommend, however, that, if an appropriation be asked, it should not be for less than $50,000.

Very respectfully, your obedient servant,

S. M. MANSFIELD,
Captain of Engineers, Brevet Lt. Col. U. S. A.

Brevet Major General A. A. HUMPHREYS,
Brig. Gen. and Chief Engineer U. S. A.,
Washington, D. C.

X 1.

SAN FRANCISCO, *March* 17, 1868.

GENERAL: I have the honor to report the following facts and suggestions with regard to the proposed survey of the Upper Colorado River.

The only information of importance I have been able to obtain with regard to the Big Cañon of the Colorado is contained in the inclosed letter from E. E. Perry, assistant geologist of the Union Pacific railroad survey, who had conversed with James White, the man who professes to have gone down the cañon on a raft. If that report be reliable, it is evident that, in the high or middle stage of the river, a strongly built boat can come down the cañon with safety. Before reading that report, I had an idea that it would be a very dangerous experiment to attempt to go down this cañon in a boat of any kind, because I feared there were falls in going down in which the boat might be upset, or even dashed to pieces; as it is, I now believe there are no falls, and I am inclined to think the best way is to start above, and descend. The reasons are that the time consumed will be very much less, and the amount of supplies, and consequently the size of the boat, will be proportionally smaller. Of what materials the boat should be made I have not the experience to form a decided opinion. A boat of India-rubber or canvas would probably be too frail and unstable; and as dry cottonwood trees are found on the banks of Green and Grand Rivers, a party of boat carpenters, provided with tools and implements, could construct a boat of a more safe character; still, a canvas boat should be carried along, as a precaution in case of accidents.

I have found it difficult to obtain any detailed information of the country near the river above the cañon. I learn that Captain (now Colonel) Macomb, United States engineers, explored New Mexico, Southern Utah, and the region bordering on the San Juan and Upper Colorado rivers in 1859, and submitted a report and map, which have not, as far as I can learn, been published. Dr. Newberry, now professor in a college in New York City, was the geologist of the expedition. If the copies of the map and report can be furnished me, they would probably afford valuable information.

I send by this steamer a map of that portion of Nevada of which we have definite knowledge. It is the one referred to in my letter of the 4th instant, as made from data collected at the joint expense of the engineer department and geological survey, and the portions left blank, south of the 38th parallel, show the amount of country unknown in that

State at present, while to the east of it, as far as the Rocky Mountains, except on the emigrant routes, we know as little. While the expense of building a steamboat at the mouth of the Colorado would be very great, I think a much greater amount of valuable information could be obtained at less cost, by starting a party from Virginia City or Fort Churchill, (both points on or near a daily stage route,) and proceeding via Paranagat to the Colorado, and there building a boat in which a portion of the party can descend the river. The party should be not less than 25 engineer soldiers, (supposing the engineer troops available,) with a wagon train and a small additional pack train, say 10 animals, to make side trips with rapid movements in search of water cr for topographical information. The mules should not usually be packed, but should be reserved for these side-trips. The wagons should start with not more than 2,000 pounds. The officer commanding the expedition should be authorized to hire a few (three or four) citizens as guides and mountain men. The whole party should be mounted. If the outfit is to be purchased from funds furnished for the expedition, it can be obtained at Virginia City; if furnished by the quartermasters' department, it should be collected at Fort Churchill.

If this plan is to be followed out this year, there is no time to be lost; and should you consider it advisable that I should take charge of the party, I think I can so arrange my other duties as to admit of my doing so.

I have the honor to be, very respectfully, your obedient servant,

R. S. WILLIAMSON,
Brevet Lieut. Col. U. S. A., Major of Engineers.

General A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

HARDYVILLE, ARIZONA, *January* 6, 1868.

SIR: The railroad survey now in progress under your direction has afforded many opportunities for acquiring valuable additions to our geographical knowledge of the unexplored regions of the far west from original sources not accessible to ordinary map-compilers.

Mining prospectors, more adventurous even than the noted trappers of the Rocky Mountains, have within the last twenty years scarcely left a mountain slope unvisited, or a watercourse unexamined, over the wide expanse extending from the Mississippi River to the Pacific Ocean. Could the varied and adventurous experience of these mountain explorers be brought into an accessible form, we should know nearly as much of these western wilds as we now do of the settled portions of our country.

Among the geographical problems remaining for the longest time unsolved, was that of the actual character of the stupendous chasms or cañons through which the Colorado of the West cleaves its way from its snowy sources to its exit into the California Gulf. Within the past ten years, public attention has been frequently directed to this subject, and various government expeditions have afforded reliable information in reference to the upper and lower course of this remarkable river. Lieutenant Ives, in 1857–'58, made a satisfactory exploration of the navigable portion of the Colorado, extending from its mouth to the great cañon, and since then a regular line of light-draught boats have been successfully traversing these inland waters. Still the great cañon remained a myth; its actual length, the character of the stream, the nature of its banks, and the depth of its vertical walls, were subjects for speculation, and

afforded a fine field for exaggerated description, in which natural bridges, cavernous tunnels, and fearful cataracts, formed a prominent feature. Now at last we have a perfectly authentic account, from an intelligent source, from a man who actually traversed its formidable depths, and who, fortunately for science, still lives to detail his trustworthy observations of this remarkable voyage. Happening to fall in with this man during my recent stay of a few days at Hardyville, on the Colorado, I drew from him the following connected statement, in answer to direct questions, noted down at the time:

NARRATIVE.

James White, now living at Callville, formerly a resident of Kenosha, Wisconsin, was induced to join a small gold-prospecting party to examine the San Juan region west of the Rocky Mountains. The original party was composed of four men, under the command of a Captain Baker. This party left Fort Dodge on the 13th of last April, and after crossing the plains they completed their outfit in Colorado City, leaving that place on the 20th of May. Proceeding by way of South Park and the Upper Arkansas, they crossed the Rocky mountains, passing around the head waters of the Rio Grande, till they reached the Animos branch of the San Juan River. Here their prospecting for gold commenced, and being only partially successful, they continued still further to the west, passing the Dolores, and reaching the Mancos, which latter stream was followed down to the main valley of the San Juan. Crossing the San Juan at this point, they continued down the valley in a westerly direction for about 200 miles, when the river entered a cañon. Here they again crossed to the north bank, and leaving the river passed across a mountain ridge, aiming to reach the Colorado River. In a distance of 50 miles, over a very rugged country they reached this latter stream, or rather its main eastern tributary, Grand River. At the point where they first struck the river it was inaccessible on account of its steep, rocky banks; they accordingly followed up the stream in search of a place where water could be procured. At an estimated distance of 12 miles, during which they were unable to follow directly along the river bank, they came upon a side cañon, down which they succeeded in descending with their animals, and procuring a supply of water. In the bottom of this ravine they encamped on the night of the 23d of August, and on the morning of the 24th started to ascend the right bank to the table land. In making the ascent they were attacked by Indians, and Captain Baker, being in advance, was killed at the first fire. The two remaining men, James White and Henry Strole, after ascertaining the fate of their comrade, fought their way back into the ravine, and getting beyond the reach of the Indians, they hastily unpacked their animals, securing their arms and a small stock of provisions, and proceeded on foot down the cañon to the banks of Grand River. Here, finding the necessary material in the shape of dry cottonwood, they constructed a raft, composed, in the first place, of three sticks ten feet in length, and about eight inches in diameter, securely tied together by lariat ropes. On this frail and clumsy raft these men embarked at midnight, on the 24th of August, with their arms and provisions, and drifted slowly down the silent current. The following morning, being the 25th of August, they made a landing, repaired their raft by some additional pieces of dry cedar, and then continued on their course. The river here was about 200 yards in width, flowing regularly at an estimated rate of two and one-half to three miles per hour. According to this estimate, in 30 miles from the place of

starting they passed the mouth of Green River and entered the Colorado proper.

Just below the juncture the stream narrows, and is confined between perpendicular rocky walls gradually increasing in elevation. From this point our adventurous explorers were entering an unknown country, never before looked on by civilized eyes. At an estimated distance of 40 miles from Green River, they passed the mouth of the San Juan, both streams being here hemmed in by perpendicular walls. From this point the cañon was continuous with only occasional breaks, formed by small side cañons equally inaccessible with the main chasm. Still they experienced no difficulty in continuing their voyage, and were elated with the prospect of soon reaching the settlements on the Colorado, below the Great Cañon.

On the 28th, being the fourth day of their journey, they encountered the first severe rapids, in passing one of which Henry Strole was washed off and sank in a whirlpool below. The scanty stock of provisions was also lost, and when White emerged from the foaming rapids, he found himself alone, without food, and with gloomy prospects before him for completing his adventurous journey. His course now led through the sullen depths of the Great Cañon, which was a succession of fearful rapids, blocked up with masses of rock, over which his frail raft thumped and whirled, so that he had to adopt the precaution of tying himself fast to the rocking timbers. In passing one of these rapids his raft parted, and he was forced to hold on by main strength to the fragments till he effected a landing below in a shallow eddy, where he succeeded, standing waist-deep in water, in making necessary repairs, and started again.

One can hardly imagine the gloomy feelings of this lone traveler, with no human voice to cheer his solitude; starving, yet resolute and hopeful; closed in on every side by the beetling cliffs that shut out sunlight for the greater part of the long summer day; drenched to the skin; sweeping down the resistless current, shooting over foaming rapids, and whirling below in tumultuous whirlpools; ignorant of what fearful cataracts might yet lie along his unswerving track, down which he must plunge to almost certain destruction; still day after day, buoyed up with the hope of finally emerging from his prison walls, and feasting his eyes on an open country with shady groves, green fields, and human habitations.

The mouth of the Colorado Chiquito was passed on the evening of the fourth day, the general appearance of which was particularly noted, as he was here entangled in an eddy for two hours, till rescued, as he says, "by the direct interposition of Providence." The general course of the river was noticed to be very crooked, having numerous short turns, the view in every direction being shut in by blank precipitous walls of "white sand-rock." These walls presented a smooth, perpendicular, and occasionally overhanging surface, extending upwards to a variable height, and showing along their sides a distinct line of high-water mark 30 to 40 feet above the then water-level. His estimate of the average height of the cañon was 300 feet, the upper edge of which flared out about half way from the bottom, thus presenting a broken and rugged crest.

During the last two days in the cañon dark-colored igneous rocks took the place of the white sandstone, which further on showed several distinct breaks on either side, till he reached a more open country, containing small patches of bottom land, and inhabited by bands of Indians. Here he succeeded, by bartering away his arms, in procuring a scanty supply of mezquite bread, barely sufficient to sustain life till he reached Callville, on the 8th of September, just fourteen days from the time of start-

ing. When finally rescued this man presented a pitiable object; emaciated and haggard from abstinence, his bare feet and legs literally flayed from constant exposure to drenching water, aggravated by occasional scorchings of a vertical sun; his mental faculties, though still sound, liable to wander, and verging close on the brink of insanity. Being, however, of a naturally strong constitution, he soon recovered his usual health, and is now a stout, thick-set, hearty man. His narrative throughout bears all the evidences of entire reliability, and is sustained by collateral evidence, so that there is not the least room to doubt that he actually accomplished the journey in the manner and within the time mentioned by him.

CONCLUSIONS.

The following may be summed up as some of the main facts to be derived from this simple narative as additions to our previous geographical knowledge of the hydrography of the Colorado River:

1. The actual location of the mouth of the San Juan, 40 miles below Green River junction, and its entrance by a cañon continuous with that of the Colorado.

2. From the mouth of the San Juan to the Colorado Chiquito occupied three days' travel, in the swiftest portion of the current; and allowing an average rate of four miles per hour for 15 hours, or 60 miles per day, would give an estimated distance of 180 miles, including the most inaccessible portion of the Great Cañon.

3. From the Colorado Chiquito to Callville occupied 10 days' travel. As this portion of the route was more open, and probably comprised long stretches of comparatively still water, it would not be safe to allow a distance of more than 30 miles per day, or 300 miles for this interval. Thus the whole distance traveled would amount to 550 miles, or something over 500 miles from the mouth of Green River.

4. The absence of any distinct cataract or perpendicular falls would seem to warrant the conclusion that in time of high water, by proper appliances in the way of boats, good, resolute oarsmen, and provisions secured in water-proof bags, the same passage might be safely made, and the actual course of the river, with its peculiar geological features, properly determined.

5. The construction of bridges by a single span would be rendered difficult of execution, on account of the usual flaring shape of the upper summit; possibly, however, points might be found where the high mesas come near together.

6. The estimated average elevation of the cañon at 3,000 feet is less than that given on the authority of Ives and Newberry, but may be nearer the actual fact, as the result of more continuous observations.

7. The width of the river at its narrowest points was estimated at 100 feet, and the line of high-water mark 30 to 40 feet above the average stage in August.

8. The long-continued uniformity of the geological formation termed "white sandstone" (probably cretaceous) is remarkable, but under this term may have been comprised some of the lower stratified formations. The contrast in reaching the dark igneous rocks was so marked that it could not fail to be noticed.

9. Any prospect of useful navigation, up or down this cañon, during the season of high water, or transportation of lumber from the upper pine regions of Green or Grand rivers, could hardly be regarded as

feasible, considering the long distance and the inaccessible character of the river margin for the greater part of the course.

10. No other satisfactory method of exploration, except along the course of the river, could be adopted to determine its actual course and peculiar natural features; and James White, as the pioneer of this enterprise, will probably retain the honor of being the only man who has traversed through its whole course the Great Cañon of the Colorado, and lived to recount his observations on this perilous voyage.

Respectfully yours,

C. C. PARRY,
Assistant Geologist Union Pacific Railroad Survey.

J. D. PERRY, Esq.,
President of the Union Pacific Railway, Eastern Division.

X 2.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., June 24, 1868.

GENERAL: In answer to the communication from the Senate Committee on Commerce of June 1, 1868, inclosing resolutions of the legislature of California, requesting information upon the necessity and propriety of legislating to aid Captain Trueworthy in perfecting the navigation of the Colorado River below Callville, I beg to state that the nature of the aid Captain Trueworthy desires from the general government not being stated, it is not possible to form an opinion upon the necessity and propriety of legislating upon the subject.

The most reliable information in relation to the Colorado River will be found in the report of Lieutenant Ives's ascent of that stream in 1858, (Ex. Doc. No. —, 36th Congress, 1st session,) but he does not describe the obstructions to its navigation with sufficient minuteness to base an estimate of the probable cost of their removal.

From his account the region at the mouth of the Colorado is a flat expanse of mud, and the channels that afford entrance from the gulf are shifting and changeable. For 30 miles above the mouth the navigation is rendered periodically dangerous by the strength and magnitude of the spring tides.

Between tidewater and Fort Yuma, which is 150 miles from the mouth, the principal obstructions are sand-bars, continually shifting, having in some places but two feet of water upon them. There are no rocks, but snags are numerous although not very dangerous.

For 180 miles above Fort Yuma the navigation is similar. The river passes through several chains of hills and mountains, forming gorges or cañons sometimes of a considerable size. In these there is generally a better channel than in the valley.

In the next 100 miles gravelly bars are frequent, with many stretches of good river; and although the bad places are worse, the channel is generally better than below. For the succeeding 50 miles there are many swift rapids; the river bed is of coarse gravel and sand, and there are also some dangerous sunken rocks. The Black Cañon, which is 25 miles long, is now reached, and in it the rapids are numerous and difficult. Callville is some six miles above the head of this cañon. Lieutenant Ives considers the foot of Black Cañon as the practical head of navigation, and that a boat of suitable model and dimensions, drawing when

loaded not more than two feet of water, should be able to ascend the river to this point at most seasons of the year.

The exploration of the Upper Colorado, and a careful examination of the lower portions of the river with the view of the removal of the obstructions below Callville, have already been under consideration, and only prevented from being undertaken during the present season by want of funds applicable to this purpose. It is intended to present, with the next annual report from this office, estimates of the probable amount required for these objects.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. of Engineers, Commanding.

Major General J. M. SCHOFIELD,
Secretary of War.

X 3.

HEADQUARTERS MILITARY DIVISION OF THE MISSOURI,
Engineer Office, St. Louis, Mo., July 23, 1868.

GENERAL: I have the honor to submit the following report of my operations as chief engineer of the military division of the Missouri for the year ending June 30, 1868:

MAP-MOUNTING AND ISSUES.

Maps mounted in one piece	135
Maps mounted in book form	210
Maps prepared for issue	479
Maps issued	623
Tracings made	86
Tracings issued	48

MANUSCRIPT MAPS PREPARED.

Kansas and parts of neighboring States and Territories; for the lithographer.

Battle-field of Chickamauga; sent to engineer bureau.

Map of Montana from surveys of Captain Raynolds, De Lacey, Geo. Stevens, Lieutenant Mullen, and Gen. Hazen; sent to engineer bureau.

Massacre at Fort Phil Kearney; reduced from original and sent to engineer bureau.

Operations near Fort Craig, New Mexico, February, 1862; reduced from original and sent to engineer bureau.

Colorado and Utah; for the lithographer.

MAPS LITHOGRAPHED.

Kansas and parts of neighboring States and Territories; 100 copies lithographed on paper, and 130 on muslin.

MAPS IN HANDS OF LITHOGRAPHER.

Colorado and Utah; 100 copies ordered.

Besides these maps and tracings the usual miscellaneous work of a topographical office has occupied the draughtsmen. Many of the tra-

cings were made for the assistant adjutant general, and for the chief quartermaster at these headquarters.

The department and posts in this military division are well supplied with all needed maps, as also the staff officers at division and department headquarters. The muslin maps of Kansas have given great satisfaction.

Expenditures from July 1, 1867, to June 30, 1868..... $9,559 78
Estimated expenditures for next fiscal year..... 8,138 16

Besides attending to my office duties I have attended to such miscellaneous work as the Lieutenant General gave me, and I accompanied the Indian peace commissioner in August and September, 1867, up the Missouri river to Plum island, just above the mouth of the Big Shyenne, to make observations for latitude. I have also prepared a treatise of iron truss bridges, which has been submitted to the bureau.

Respectfully, your obedient servant,

WM. E. MERRILL,
Major Engineers and Brevet Colonel.

Brevet Major General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

X 4.

Report of Lieutenant R. W. Petriken, Corps of Engineers.

SIR: I have the honor to make the following report, accompanied by map of the route passed over by Brevet Major General Augur, commanding the department of the Platte during the summer of 1867. General Augur's route will be seen on the map indicated by broken red lines.

Starting on the 1st of June from North Platte City, the then western station on the Union Pacific railroad, at the junction of the North and South Forks of the Platte, and proceeding up the South Fork on the north bank as far as the mouth of Crow Creek, a small stream flowing from the Black Hills, up Crow Creek, crossing twice to within about 14 miles of the site of Fort D. A. Russell, here leaving Crow Creek to the left, passing to Lodge Pole Creek, striking it about 11 miles from the entrance to Cheyenne pass, old Camp Walback; then going north on old road to Fort Laramie, struck Cherrywater, down which this road passes as far as Cherry Spring, thence across country to Fort Laramie; returning by same road to within a few miles of Cheyenne pass, when, leaving it to the right, crossing the two branches of Pole Creek two or three miles from these cañons, also the branches of Crow Creek, and down Crow Creek on the south side until opposite the site of Cheyenne City, at which place we crossed to the north side. Remained in camp about two weeks, during which time Fort D. A. Russell was located, two and one-half miles west of Cheyenne, fourteen miles from the Black Hills, on a fine plateau on the north side of Crow Creek. Government reservation two miles wide by three miles long, length north and south magnetic meridian.

On leaving this camp went to Fort Sanders by Evans's pass, and returned by Cheyenne pass, striking across country from the pass to Fort Russell. Evans's pass is on the south side of Crow Creek, and the route taken by the Union Pacific railroad. From Fort Russell traveled east and north as indicated, passing over to Pole Creek and down it, finding the end of the track of the Union Pacific railroad about 20 miles below Pine Bluffs, at which place we embarked for Omaha.

On leaving North Platte City, June 1, 1867, found the road in bad condition—soft. This was only while on the low land bordering the river. When on higher ground, along the foot of the bluff, the road was good. The construction of the railroad to Cheyenne and beyond obviates the use of these roads along the Platte. The country from North Platte City to Cheyenne has but few redeemable qualities. Some of the land along the South Platte is susceptible of cultivation. All is more or less impregnated with alkali. In the vicinity of Fort Sedgwick the country is very barren. In the bluffs and about one hundred feet above the stream a horizontal strata of soft clay limestone was noticeable until when in the vicinity of Fort Morgan, Colorado Territory, about forty-five miles west of Fort Sedgwick, noticed the three remarkable rocks as represented on map, and also on map of department. The valleys of the small streams leading in the Black Hills can be made productive, namely, Crow Creek, and to the north, Lodge Pole, Horse, and Cherrywater creeks, of which Cherrywater is the largest; and south, Lone Tree, Box Elder, and the Cache la Poudre, the valley of the latter said to be a fine agricultural country; the stream said to be large and rapid. This valley produces at present almost enough to sustain the inhabitants of Denver and Cheyenne City. The vegetables are the best I have seen, especially the potatoes, of which a great quantity is now purchased yearly by the United States. There is no doubt that the valleys of the other small streams of this vicinity will produce as well. At the foot of the Black Hills there is a valley running north and south, having the hills on the west and an elevated plain on the east. The streams flowing from the hills and to the north of Lone Tree cross this valley, running nearly east and cutting through the aforesaid plain. From appearances this valley has been the bed of a lake, with the several branches of Crow, Pole, Horse and Cherrywater creeks emptying into it. In this vicinity there is a rocky bluff at the eastern base of the Black Hills, extending from Lone Tree to the Cherrywater, through which all the intermediate streams cañon; these streams head on the back bone and receive supplies of water from the eastern slope of the hills proper, the declivity of which is very gentle, and extending down to the base of this rocky ridge. The western slope is much more abrupt, especially from the railroad line north. The divide between Lone Tree and Crow Creek is the only place where on the eastern slope the foot-hills extend out to, and connect with, the plain spoken of above. It is by passing up this divide that the railroad is enabled to attain its great elevation at such low grades—summit 8,200 feet above tide water.

The small streams flowing from the Black Hills have water in them the year round for a distance of about 50 miles from their sources, when they sink in the sands, probably to appear again below. Water can be had at any place in their beds by digging. The rocks of the region of the Black Hills are of a primitive formation; granite, syenite, and the accompanying kinds. On the Cherrywater great quantities of magnetic iron ore is to be found scattered over the ground, indicating that above these must be a large amount in place. I was unable to look for it. No other ores of any value were found. Timber is very scarce in this region; none to be found except a little cottonwood along the stream, and some Norway pine on the hills and Dead Pine Bluffs. Grass of the best qualities abounds, making all this dry country available for grazing purposes, to which it is well adapted, being on the eastern side of the mountains, and protected from the northwest wind, the prevailing wind. The whole country is nearly, if not entirely, destitute of flowers; with perhaps the exception of the cactus, there are none of any beauty. The roads in the

vicinity of the mountains are good, hard and smooth at all seasons; the soil being composed of small pieces of feldspar. From Fort D. A. Russell there are good roads in any direction. From the number of roads indicated on the map in this vicinity, it will be seen that wagons can be taken over any portion of the country east of the Black Hills, except, perhaps, over some portions of Pine Bluffs.

I have indicated in black ink two new and direct routes from Fort Russell to Fort Laramie, and also the telegraph line. I have also indicated in black ink Colonel Merrill's route to Fort Fetterman. These roads are reported by him to be good. There is wood in abundance on all the roads now used by the government in transporting from the depot at Fort Russell to any of the posts north or west, after reaching the hills fourteen miles west, and the Cherrywater two days' march to the north, this requiring that supplies necessary for two camps be taken by heavy trains. Water is good on all these roads, and marches easy and short.

Respectfully, your most obedient servant,

R. W. PETRIKIN,
First Lieut. of Engineers, Eng. Dept. of the Platte.

Brevet Major General A. A. HUMPHREYS,
Chief Engineer U. S. A., Washington, D. C.

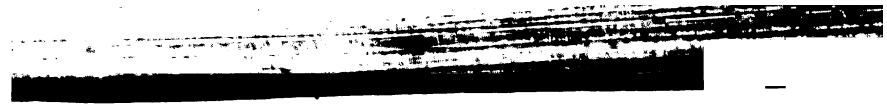
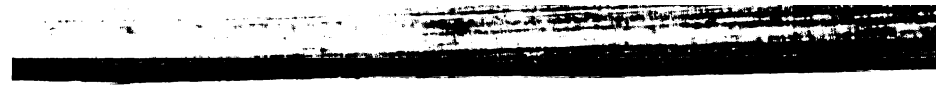
X 5.

Report of Brevet Brigadier General N. Michler, Major Corps of Engineers, upon survey of battle-fields and maps of campaigns and battle-fields.

By orders from headquarters corps of engineers, communicated by letter of July 9, 1867, authority was given me to continue the surveys of the several battle-fields in which the army of the Potomac had been engaged, comprising those of the North Ana, Todd's Tavern, Wilderness, Mine Run, Chancellorsville, Fredericksburg, Antietam, and South Mountain. With the exception of Gettysburg, these surveys would complete, in addition to those enumerated in my last annual report, the entire campaigns of that army during the war.

A party was organized under the immediate direction of Major John E. Weyss, who has been for many years my principal assistant, and operations were commenced in the field on the 20th of September, 1867. The survey in Virginia was continued without interruption until the 5th of November, and in that time 212 square miles were completed, including seven of the battle-fields above mentioned. The party was then transferred to Antietam, commencing the surveys in that locality on the 17th of the same month; they were continued until the 5th of December, when the extreme cold weather, accompanied by heavy snow-storms, compelled it to suspend further work. The area surveyed comprises fifty square miles; this was connected with surveys of Harper's Ferry and Maryland Heights, made by Major Weyss, under my direction, in 1863; the whole section covers about 88 square miles. On account of the lateness of the season and the severity of the climate, the survey of South Mountain could not be prosecuted, and it is respectfully suggested that the same party be sent before the commencement of the winter to complete what forms so component a part of the battle-field of Antietam. The surveys above enumerated were made in great detail and have since been plotted; the maps, seven in number, are far on towards completion, three being

entirely finished. Some additional material is still wanting to explain and more fully illustrate the movements of the army of the Potomac, such as more perfect surveys of the approaches to the different fords from the north side of the Rappahannock, and of the country between Mine Run and Clark's Mountain. A list of the completed maps and drawings was furnished in my last annual report, to which those above enumerated, drawn on a scale of four inches to the mile, are now added. The entire portfolio now numbers 186 sheets of antiquarian, comprising general and detailed maps of campaigns, sieges, and battle-fields, with numerous drawings of forts, redoubts, batteries, and mines. An examination of the maps exhibits the great detail with which the surveys were made and the beauty of their execution. Major Weyss and his assistants are deserving of the greatest credit for the rapidity and accuracy with which the work has been accomplished.

Respectfully submitted,

N. MICHLER,
Major of Engineers, Brevet Brigadier General.